THE INSTITUTION OF PRODUCTION ENGINEERS JOURNAL

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PRODUCTION ENGINEERS JOURNAL

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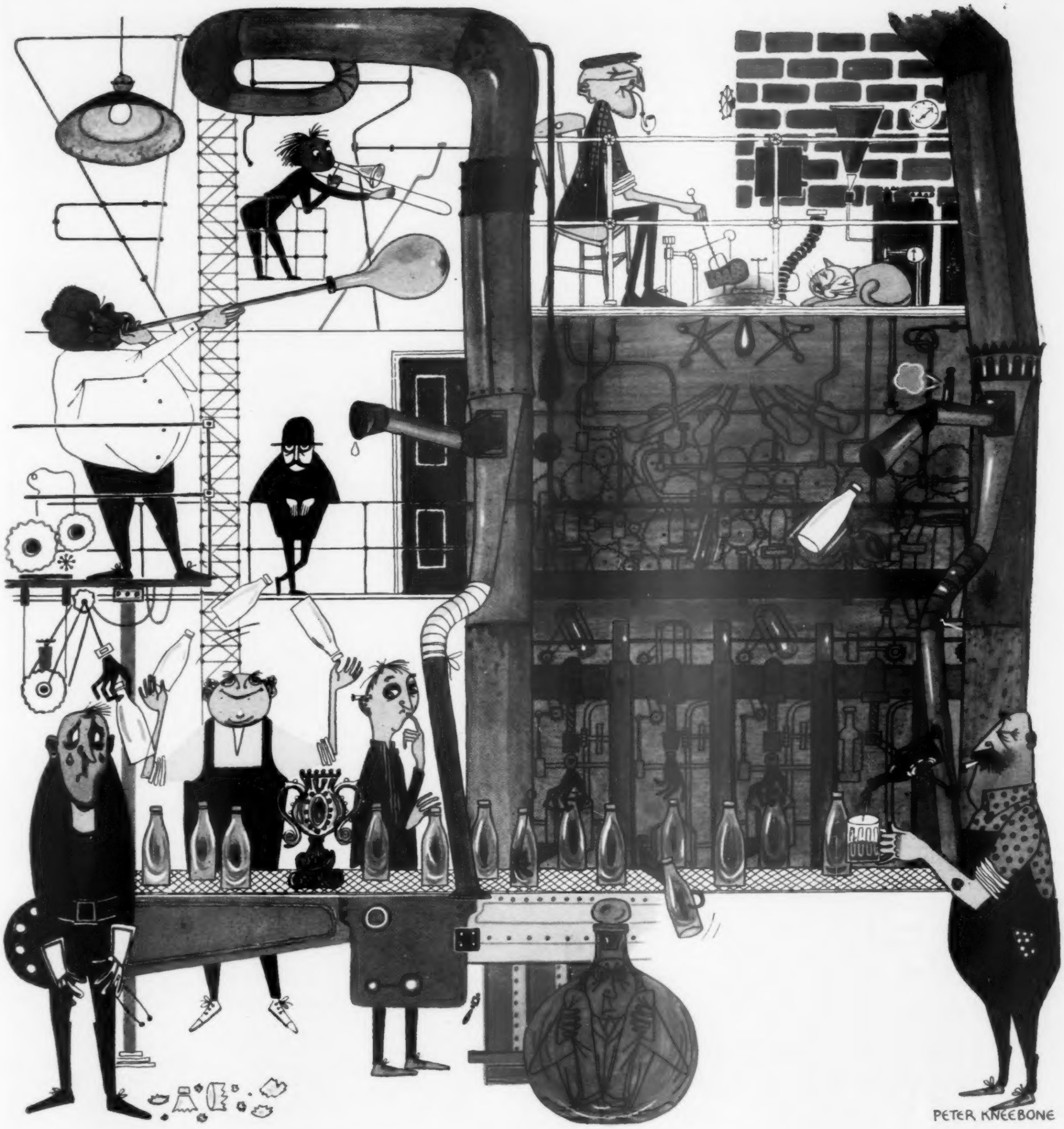
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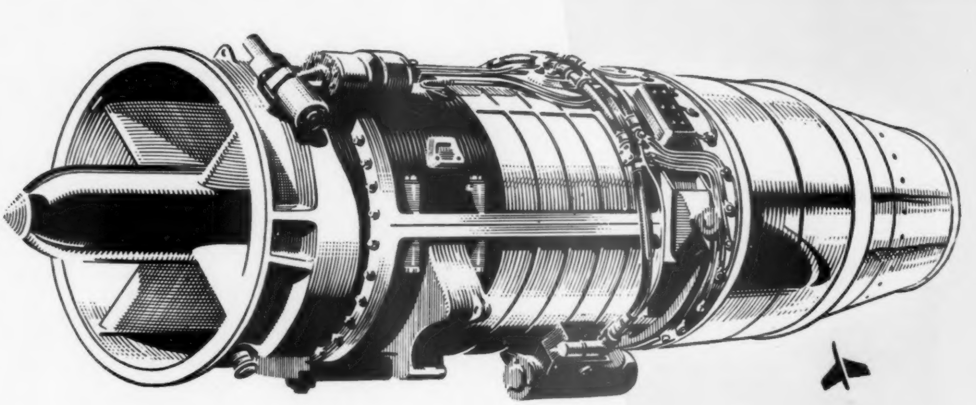

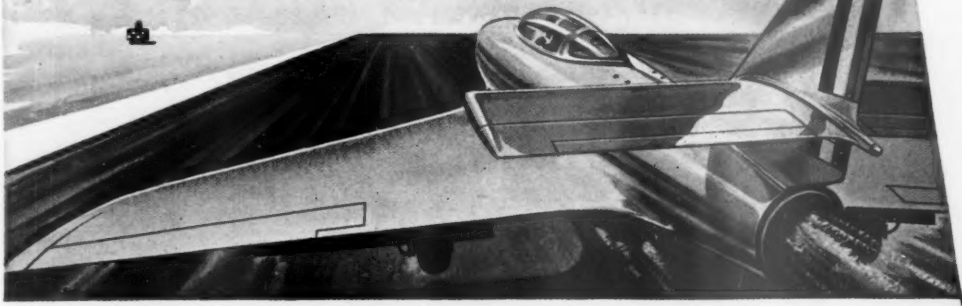

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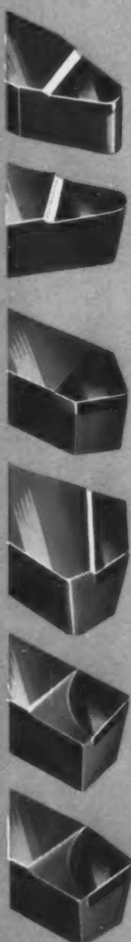

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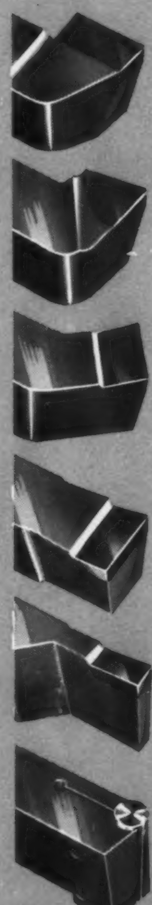

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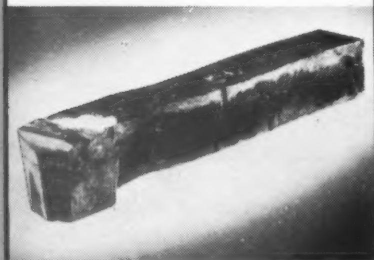

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Presentation

to

Sir Walter Puckey

Vice-Chairman of Council, 1948-50
Chairman of Council, 1950-52
President-Elect, 1952-53
President of the Institution, 1953-55

30th June, 1955

Sir Walter receives the salver (shown below) from Lord Sempill. On the right are Mr. Donald Kaberry, M.P., Parliamentary Secretary to the Board of Trade, and Mr. G. R. Pryor, Chairman of Council.

Presentation to Sir Walter Puckey

AN unusual and pleasing ceremony took place at the House of Lords on Thursday, 30th June, 1955, when the Right Hon. Lord Sempill, A.F.C., a Past President of the Institution, gave a dinner in honour of Sir Walter Puckey, retiring President of the Institution, to mark his completion of seven years' continuous service as a Principal Officer. He presented Sir Walter with a silver salver inscribed with the signatures of members of the Council in the United Kingdom.

Invitations to attend were sent to all members of the Council in the United Kingdom, and 32 members were able to be present, together with the Secretary of the Institution.

The Sections of the Institution outside the U.K. were represented by Mr. H. le Cheminant, a Past President of the Australian Council, who by a happy coincidence is at present on a visit to Britain. Also present was the Parliamentary Secretary to the Board of Trade, Mr. Donald Kaberry, M.P.

Lord Sempill said he found it difficult to express his pleasure at seeing so many old friends—production engineers all—on such an important occasion. He knew that his friend, the Parliamentary Secretary to the Board of Trade, shared his pleasure that the Lord Great Chamberlain had been persuaded to allow a function of this kind to take place in the House of Lords. The Lord Great Chamberlain had, of course, many applications for permission to dine and it was not at all a simple matter to obtain his consent, but when he heard that the purpose of the Dinner was to honour Sir Walter Puckey, he gave his gracious consent.

A Great Debt of Gratitude

"All of us here" continued Lord Sempill, "who are engaged in the art, practice and application of production engineering, owe, as fellow technicians, a great debt of gratitude to Sir Walter, and also in parallel with this and perhaps in a more important sense, as subjects of this country which in the last century was the workshop of the world, and in this century the leader in the invention, development and manufacture of new devices but dimly contemplated by others.

"It is by no means easy, as you will realise, to pay tribute to so outstanding a personality. I know that at times like this it is customary to exaggerate, but I have no need of this, since you know well he was selected by the Minister to advise the Ministry of Supply on vital production questions and he is our national and technical leader in the field. We are proud indeed that this great honour went to one who today is our President. However, it was neither you nor I who had to make the decision to give up, as did Sir Walter, one of the most interesting and important jobs in the country to do a *pro bono publico* service for the love of that cause of freedom in which Britain is and ever will be, I fully believe, the leader.

"Did Sir Walter hesitate for a moment and say, as is always said by the large majority today; 'What do I get out of it? Where do I come in?' Not a bit of it! He rallied to the Minister's call, threw up his job and placed his vast accumulation of scientific and technological experience at the disposal of the Minister for the good of us all. I say to you without fear of contradiction that what we want is more Puckeys, and if we could have them, you would not be able to see our country for the vapour trails!

"We are all particularly grateful for the presence of the personal representative of the President of the Board of Trade and in particular the Minister of State. We look forward with very real pleasure and a certain amount of proper awe to the guidance that he will give us and, we feel sure, the appreciation he will express where we have done well. I think that, by implication, his directive will also carry the authority of the Minister.

"It will be a great pleasure for me to hear Mr. Kaberry speak. It will be the first time I have done so. However, when I tell you that he is a distinguished member of Clan MacKenzie you will agree that we may expect something very firm and very definite.

" With regard to the technological matters, I am going to leave them to be dealt with by our President, who is able to explain intricate matters with great clarity, since he has learnt what the late Lord Balfour, one time Prime Minister, said in this House : ' the generality of people much prefer the continuance of a problem they cannot explain to an explanation which they cannot understand.'

A Vital Part of Production Engineering

" Therefore, I am not going to touch on the technical side of our work, but I should like, in concluding my remarks, to put one thought in your minds, that is, that transportation is an essential and vital part of production. We cannot, as we aim to do, maintain and increase the real wealth for our country without it, and in these modern days it should be much more efficient than it is.

" Some of you may remember that President Hoover set up a commission to look into the costs of the average article that the United States citizen buys. Their report showed that the average cost was made up, broadly speaking, to the extent of about 60% of a transport charge in some form or another. That, therefore, very much fortifies my argument that we production engineers must have the finest system of transport.

" We know, too, that to-day the bulk of the goods in this country are being carried by road transport. Road transport contributes in one way or another some £400,000,000 a year in taxation, although a very insignificant proportion of that sum is received back for the benefit of the roads. Recently we were told that British Railways, undoubtedly the pioneer in world railway systems, is to be greatly modernised, and that for a start the sum of £1,200,000,000 is to be spent to this end.

" I suggest to you that this will not give us the effective transportation system that is vital to our existence. I am convinced that there is a very good case for converting some of the railways to roads, and this is a question well worthy of further study.

" In any case, transportation is an essential part of production engineering. We should think closely about it. We have passed the time when we can continue, as we have done in the past, to be the pioneer nation in all things. Time will not allow us to indulge in excessive experimentation. We must now take stock of what others are doing, and when we find, as we do in regard to the question of road engineering and construction, that the Americans are showing the way, surely we should be honest and follow them more closely.

" In my view, there is an unanswerable case for doing over road construction, what that great statesman—referred to only yesterday by the Secretary of State for Foreign Affairs— Mr. Ernest Bevin, did, in regard to aerodromes. This applied, of course, to a war situation, but we are certainly in a vital trade war, as I am sure the Parliamentary Secretary will emphasise when he speaks. At that time, Mr. Bevin saw that unless the necessary aerodromes were available in France we should be in an impossible position. So he selected the finest administrator and civil engineer that the country could produce and told him what he wanted him to do. He asked this civil engineer how many men he would need to do it. The civil engineer told him how many, Mr Bevin gave him the manpower and the job was done. The man who did this, as you well know, is our Past-President, General Appleyard.

Wastefulness of Internal Dissension

" We want to get on with the job of tackling the road problem in the same sort of way. To-day we are fighting altogether on too many fronts, and most of them are all wrong because we are fighting only ourselves. All this internal dissension is not only a waste of time but makes other countries wonder what we are doing. Until we pull ourselves together and see that the world will not wait while we bicker, we shall continue to lose not only business but, what is even more important, the respect of the world for a country which has over the centuries been able to show countless millions how to live.

" My final words are that we should surely take to heart the words of Sir Winston Churchill when he said quite recently : ' The power of man has grown in everything except over himself.'

" Before calling upon Sir Walter, I want to confess to him on behalf of you all that we have had secret meetings to which he has not been invited. We decided that we must commit to permanent record our feelings of affectionate admiration and gratitude, so we have engraved our signatures on this silver salver, which we know will find a place of honour on the family sideboard."

Lord Sempill then called upon the Parliamentary Secretary to the Board of Trade, Mr. Donald Kaberry, M.P.

Mr. Kaberry said that his task was extremely simple. He wanted to propose on behalf of those present the toast of the good health of Sir Walter Puckey, to wish him good fortune for the future, and to offer him many thanks for the good work that he had done in the past.

Mr. Kaberry knew that they would wish him first of all, on their behalf, to say " Thank you very much indeed " to Lord Sempill for the very great hospitality that he had extended to them that evening. It was a great honour for the Institution to have him associated with it. For that reason alone, Mr. Kaberry, on behalf of his colleagues, was very proud indeed to be present and to say a few words in association with and in supplement of, the things that Lord Sempill had said.

He would like to pay tribute to Sir Walter Puckey, a man who had shown in his own career what a man of ability could achieve. He knew of the fine work Sir Walter had done in the Ministry of Supply, and he had heard on all sides that during his Presidency of the Institution he had been a forceful and wise director of its fortunes.

However, the Institution was very fortunate to have a great successor to a great President, and Mr. Kaberry was sure that in Sir Leonard Lord, who had passed through all the stages of the engineering industry, the Institution had someone who, it could rest well assured, would prove as worthy as any of the previous holders of the office had been.

Mr. Kaberry believed that the Institution of Production Engineers was largely connected with the subject of what was popularly known as productivity. He was emboldened to say a few words because of his official association at the moment, and also because before he had shed the more lucrative position which he had before he assumed his present garb of poverty, he was associated in a small way with the engineering industry in his own city of Leeds. He had had the good fortune to attend a dinner held by the Institution there.

A Great Achievement

" I know, in fact ", continued Mr. Kaberry, " how much you are doing as an Institution to advance the techniques of production, and I may assure you that my colleagues are particularly impressed by the success which you have achieved. It is worthy of note that the output per man per annum in industry in this country has risen by 19% since 1948. That is a great achievement on your part. It is good, but let us hope that you can do still better, because you have the touch and the intimate personal association which others have not got, the new ideas, the inspiration and encouragement, and the right word at the right time.

" Surely we all accept that the greatest need in British industry is better productivity, greater output per man hour, and greater utilisation of mechanisation ? Whatever technical advances we make, I think we must have the wit and the wisdom to use them properly. Otherwise it is vain, in all senses of the word, to talk about doubling the standard of living in our generation. As I see it, the men behind the machines in all grades of industry must work contentedly together. I hope that automation or the automatic factory, whatever it may mean for the future, will not mean identical standardisation, a uniform product with no variation of any kind. Copying, duplication, triplication, whatever it may be, is boring to the *nth* degree and can have its difficulties.

" It is in the end the men behind the machines who will count, and to achieve this should, I think, be the principal domestic aim of both Government and industry. You, and many like you, are doing much to achieve this, and your schemes for better technical knowledge, education and informed discussion of industrial problems are of the greatest value. I can assure you that we in the Government intend to do all we can to back you up in this. We intend to further our schemes for higher education, both general and specialised. We shall do all we can in every way to ensure that the rising generation is fully equipped technically to take its proper place in industry in the fight for our national survival.

Better Working Conditions

" There is a wider field, too, in which the Government must give encouragement—to use no bigger word than that—by seeing that the older factories in this country are replaced by newer ones in which it may be, if not a pleasure, at least comfortable to work. I am glad to say in this connection that the area of new factory space provided for manufacturing industry in the first quarter of 1955 was the greatest for any quarter since the War and about two-thirds higher than in 1954. That is a great achievement, but we shall see greater things in the future in which members of this Institution can play a great part. We are on the verge of a new era, a period of clean air and smokeless fuel, power produced atomically and so on. I know that the members of this Institution will not be behind in adapting themselves to the changed circumstances which can lead to greater productivity and greater happiness and contentment for all.

"In that connection, what is most important of all—and I ask for the help of everyone in this matter—is to get all sides of industry on better terms with each other. I venture to suggest that our Prime Minister has given a great lead in this. We all know that, already, in the short lifetime of this Government he has met representatives of the British Employers' Confederation and of the Trades Union Congress, and that in the next few days he is to meet representatives of the nationalised industries. So far as the Government can go, the lead will be given for better understanding between all sections of industry.

"However, everything cannot be left to Prime Ministers and Ministers of all ranks—I hope you note that very seriously, because I do, it is so abundantly true. Everyone in a position of responsibility —as is everyone here tonight—has a duty to help in this national drive for better understanding in industry. Otherwise, quite frankly, all exhortations to produce more and to export more will be quite useless. For example, as you will know, on paper the export figures for the engineering industry are very good. In the first quarter of this year engineering exports were 10 per cent. higher than a year previously.

"At that point a politician pauses for cheers—but here is the rub. The reason for this is partly, and unfortunately, the backlog built up by the dock strike last October; and we are not asking for a dock strike each October as the years roll by.

A Challenge to the Institution

"This strike, and others, presents a challenge o this Institution. One has to face the fact that working days lost by industrial disputes take many more days to overcome. Next to a general strike, a dock strike is the most fatal blow that our country can suffer. One hears of examples of orders lost through strikes. In connection with my own city of Leeds I know that there are many thousands of pounds' worth of worsted goods held up at docks in this country. The fear has been expressed that this will give Italian worsted manufacturers opportunities of which they will be quick to take advantage.

"I will take that as the second point and lead on to the question of foreign competition. It is no good our whining about foreign competition. It has come, and it is not going to go away of itself. We have got to become more competitive than ever if we are not to see our ex-enemies beating us on a different battlefield. We all know the old stories about delivery dates. I think we all hoped that they were things of the past. Despite all our difficulties let us hope that this is so. However, I would point out that many reports made to the Board of Trade show that the feeling exists in most industries that the hold-up in arrangements caused by the dock strike may seriously undermine confidence abroad in our ability to observe such dates in the future. What is worse, this applies more particularly to new markets which we have recently penetrated for the first time.

"I hope I have not been too depressing a guest, for there is, in fact, a brighter side to the story. The British economy is fully employed. I am fascinated by the statistics that I have been given—that in May the unemployment rate was down to 1 per cent. and that there were more than 1½ vacancies on Ministry of Labour books for every person who is unemployed. This is, however, unevenly distributed and it presents many delicate and detailed problems for those of us who are concerned with the overall situation. There is no question that in some parts of the country there is over-employment and in some other parts under-employment.

"Over the whole country, the picture looks a reasonably satisfactory one. Output, except for coal and cotton, is generally up on a year ago. The index of manufacturing production was 7½ per cent. higher in the first quarter of 1955 than in the first quarter of 1954. There is every sign that industries generally are planning long-term expansion. Factory building approvals, which I have already mentioned, and new orders for machine tools, which together are the only current indicators of investment, are both 60-70 per cent. higher in the first quarter of this year than in the first quarter of last year.

"This is, broadly, a good picture, but it is a picture which presents for all time a challenge to maintain the position and to go on to better times in a rapidly changing world.

Signs of Expansion—and Danger

"Everywhere there is, in fact, a sign of a vigorous expansion in British industry. There are signs of danger, and the danger is one with which the members of this Institution and men of their calibre are particularly fitted to deal. It is the national danger of manpower gone to waste, either through its own or through someone else's ignorance. We cannot afford that for the future. The Government can and will help, but the problem is largely in the keeping and for the solution of industry itself. It is for you to see that our problem is solved, and I can assure you that the Government will give you every possible assistance that they can.

" To that end, therefore, I give you the toast to one who has played a very great part in the working of your Institution. In wishing him good health and good fortune for the future, I would extend through the toast my good wishes for the good fortune and prosperity not only of this Institution, but of every industry with which it is associated. In your hands is, very largely, the future and the welfare of the generations of this country who are to succeed us.

" I ask you all to rise with me and drink the toast of Sir Walter Puckey ".

In response, **Sir Walter Puckey** said that it was not often that he was at a loss for words, but he was deeply moved by the occasion and by the honour done him by so many old friends. He was very grateful.

He was also surprised and delighted by the fact that he had been kept in ignorance of the arrangements until tonight. It added, in some way, if anything could add, to his great pleasure in being there, in the presence of so many friends with whom he had worked over many years.

It gave a man very great satisfaction indeed when he realised that people whom he himself had tried to help and people who had helped him in no small measure were gathered together on such an occasion. One saw, perhaps, a certain continuity, realising that although Presidents might be transient and Chairmen of Council might come and go, the fact remained that in a body of the nature of the Institution, there was a continuity of inspiration, of thought and of work which he believed would keep the Institution on the high plane on which it stands today.

For example, remembering his own term of office as Chairman of Council, what a great delight it was to see present men like John Hill and Harold Burke, who preceded and followed him as Chairmen of Council! How gratifying also it was to see there Mr. Pryor, the present distinguished Chairman of Council, so well recovered from his operation!

On the Presidential plane, which was of course far below that of the Chairman of Council in importance, what a delight it was to see his predecessor in office, Sir Cecil Weir, and *his* predecessor, General Appleyard, and to realise, as he had said at Margate, that old soldiers never die but just go on being hard-working ex-Presidents of the Institution. How good it was to have that continuity of service!

" Some mention was made a little while ago " said Sir Walter, " of an overlap. If I were to say to you that I have finished my work for the Institution, I should naturally be disclaiming the very virtues about which I have just been speaking. Other people have laid down the Presidential burden, but they have by no means laid down their work for the Institution. I have told our Chairman of Council that he may rely upon me to do what little I can in the interests of the Institution, despite the fact that I shall go into what one might call Presidential oblivion in about two or three hours' time!

Is the Institution Necessary ?

" Before handing in my Presidential chain, I should like to mention a few things I have thought about as your President. Every man occasionally looks at his job and says to himself: 'Am I really doing the necessary thing, or is there something else that I could be doing better ?' I have looked at our Institution, in which I have spent quite a fair amount of my voluntary time, as indeed all of you have, and I have said: ' Is this Institution really necessary?' There are certain things against us and let us be quite frank about them. First of all, the national cake, maybe, is being divided up into too many small slices, and perhaps there is too much specialisation today. It is very much easier to divide ourselves up into narrower specialisations than to combine together into a really effective national cake. There may be the feeling, too, that other Institutions, older than our own—we are quite young really —should perhaps be doing the job that we are doing.

" Increased specialisation brings other difficulties. It is becoming increasingly difficult for senior members to find the time to speak at the many meetings called by all sorts of bodies, even to attend those meetings. I and many of you in this room are constantly being asked to give Papers to an even wider series of meetings, and we sometimes have the impression that there are far too many bodies calling upon far too few people; we feel that if someone could simplify the structure in this field we might do better.

" There is also the feeling, which I am sure the Parliamentary Secretary will not mind my mentioning, that the Government itself does not wish to encourage too many bodies with which it may have to deal, and in my own term of office as a temporary Civil Servant, I realised fully from the inside how difficult it is to deal with more than a small number of bodies effectively and how important it is to have well-trodden paths of communication with certain groups which are widely representative.

The Other Side of the Picture

"That is one side of the picture. Let us turn over the medal and look at the other side.

"First of all, as has already been said, there is a great need today—and an even greater need in ten years' time—for more production and more productivity. I do not know how many of you would agree or disagree with the figures that I ventured to put before the Conference at Margate in my own Paper, but I and a number of statisticians endeavoured to calculate what we thought were the productivity aims required to achieve Mr. Butler's target of doubling the standard of living in 25 years. If you meditate on those figures, you will see that whatever has been our increase rate of productivity, and I believe it has been very good over the last 10 years, it has to be very much better over the next 25 years. For this we look to the field of production and productivity—to the people whose job it is to produce better quality, greater volume and on time.

"Again, we have been told by many—by politicians, economists, scientists, perhaps by everybody except ourselves—that the biological chain, as it were—the industrial chain in this country—has one weak link, the link of production. Britain is proud of her scientific discoveries, but we are constantly told that we are not very good at translating these discoveries into practice. We are reminded that in America, for example, there is a rate of productivity of the order of 3 : 1 as compared with ours. The inference is that there is a strong need to complete the chain and to strengthen the weak link of production. There will be even stronger need tomorrow when the flood of scientific effort makes it even more difficult for production to follow closely behind.

"Therefore, it seems to me there will be an even greater need for production engineers in the future and, by inference, for an Institution which sets the standards, trains the men and provides them with all the satisfaction that a good professional Institution can provide.

"While on this subject, and in the presence of the Parliamentary Secretary, let us look, too, at the vast expenditures on scientific research upon which Her Majesty's Government have embarked, of which many of you have intimate knowledge.

"I said at Margate that well over 50% of the total electronics research in this country today is on Her Majesty's Government's account. Such official activities, plus the vast amount of scientific research going on in all the industrial firms and research bodies of this country, mean that an ever-increasing flood of scientific invention will be thrust upon you, for translation into saleable goods. If you are not successful, Britain will not maintain her place in the world.

"You have, too, another important task, and I was glad to hear it touched upon by the Parliamentary Secretary. It is the marriage of man and the machine. Automation is a word which frightens some people. There is the feeling in some minds that the marriage of man and the machine will produce not better men, but a lot of little automatons running around. You and I think that the marriage will produce bigger men. You are the people who, more than any other group in the country, are capable of making this a happy marriage. There are some who are concerned primarily with the machine; there are some—sociologists and others—who are concerned primarily with man. You are the people linking the machine and the man; you have to preserve the balance and that is a vital task. I know of no other Institution in this country which is more concerned with linking these vitally important sections of our life. The greater the volume of the research, the greater will be the complexity of the machine, and the greater will be the problem of the man. It is your job to see that they are married effectively.

The Institution's Achievements

"What have we achieved? We are a young body and one thing that struck me particularly at Margate was the large number of young members of the Institution present, many deliberately sent there by the older members to learn something about the future which they will have to control. What sort of Institution are we handing over to these young men? Perhaps we have had a few failures, but I believe the successes overwhelm the failures. Let us survey the record.

"The Parliamentary Secretary told you of the national increase in production. Somebody must take some credit for that, and I feel quite sure that Her Majesty's Government would allow a certain amount of that credit to be given to people like yourselves. It has been achieved by somebody by solid hard work on the part of people like yourselves. I hope the Parliamentary Secretary will feel that that is a reasonable assumption on your part.

"As far as production men are concerned, there has been a remarkable growth in their salaries and status during the last few years. Do not let us assume that our work is measured solely by the number of noughts after the first figure in our salary. It is important to realise that even today the status of 'production' is not fully established in the mind of the average man-in-the-street, although this is not

the only reason why so many firms today are failing to get good production men in spite of high salaries which are offered. But, whatever the reason, the shortage of trained production men must be counted as one of our failures.

A Universal Requirement

"One of our successes is that today we see greater demands by all industries for production engineers. Many of you have done and are doing a great deal about what we call broadening of the base. If you look at the advertisements in the Institution's Appointments Bulletin, you will find an ever-increasing demand, from an ever wider range of British industry, for men with production experience. That is very significant, because although we were born in one section of the engineering industry, more and more people are realising that production is a universal requirement and that trained production men are universal assets.

"What have we done to help in the training of more and better men? The technical colleges of this country have done a very great deal indeed. Thousands of Higher National Certificate men have gone out from our technical colleges, and are providing the bulk of our young entrants into production engineering.

"The universities, too, are becoming increasingly concerned with production engineering and last week I had an experience in Manchester which it is difficult to imagine happening 10 years ago. The Manchester College of Technology decided a year or so ago to set up an honours degree course in production engineering, and I was asked if I would be an external examiner. Last week I went to Manchester and spent a most interesting time; the interest of the Principal and the senior staff, and their desire to do more to educate better men for production engineering, was a very heartening experience for me.

"I believe that the public is recognising more and more the worthwhileness of production engineering as a profession for their sons. I have been struck—I expect that many of you have, too—by the invitations to present prizes at grammar schools and a similar educational establishments where formerly they did not know what production meant. Today the headmasters are saying: 'We must let the teachers and parents find out more about this sort of thing'.

"We can count these changes among our successes but, as I said earlier, we have had a few failures, too. If you refer to the press and our own Appointments Bulletin, you will find that we are not satisfying the demand which we have created and that is a bad thing. It is undesirable to create a demand for better production engineers if we do no provide equally good facilities for producing them. This is a great challenge to us.

"I think that we have partly failed, too, with Her Majesty's Government's representatives. Despite the heartening and worthwhile words that we have heard this evening from the Parliamentary Secretary, I do not believe that, by and large, Her Majesty's Ministers have yet fully recognised the production function.

"A very great deal remains to be done, not only to make certain that, for instance, the Ministry of Supply continues, as it will, to initiate research and encourage scientific investigation in a variety of fields, but also to make certain that more encouragement is given to those whose job it is to satisfy Her Majesty's Government about production.

Future Trends

"What are the significant future trends? First of all, I think we have to produce more production engineers. Secondly, I think that we must recognise even more, and we must train our younger fellows to recognise even more, that we more than any other group, are the balancing, co-ordinating force between man and the machine. I said once that a production engineer could be likened to 'a doctor attending to the birth of a third dimension'. You are attending to the birth of both mother and child. Usually, we take great care of the child; we see a new idea coming forth and are very wrapped up with it, forgetting the basic fact that it was a human being that produced the child. I believe that we must more and more recognise that our important job is to link man and the machine for the benefit of man. The greater the technical change, the more strikes and other forms of industrial unrest will occur, unless we do our job better.

"The Parliamentary Secretary is rightly disturbed about the present industrial situation. We have some of what in this country we commonly call joint consultation, but I believe we have far too little of it. We have far too little real mutual understanding between managers and men and sometimes between managers and managers. Production engineers, of all people, understand the machine and must at the same time persuade other men to accept the changes brought about by the machine. This means much more real joint consultation than is being practised today.

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MARGATE CONFERENCE

SECOND PLENARY SESSION

TECHNICAL AND HUMAN PROBLEMS OF THE AUTOMATIC FACTORY

by The Rt. Hon. The Earl of Halsbury, F.R.I.C., F.Inst.P.

Lord Halsbury

The Earl of Halsbury has been since 1949 Managing Director of the National Research Development Corporation, which was set up under the Development of Inventions Act, 1948, mainly to ensure the development and exploitation of inventions resulting from public research.

Born in 1908, Lord Halsbury was educated at Eton, and on leaving went into the City to study chartered accountancy. But he soon turned to science, and as an external student of London University took a B.Sc. degree with first class honours in chemistry. His first industrial appointment was with Lever Brothers at Port Sunlight.

During the war, at the research laboratories in Sheffield of Firth Brown, he worked on the design of special steels for the blades of gas turbines and jet engines.

In 1946 he became Research Manager and later Works Manager of the Decca Record Co., Ltd. At Decca's his main research target was the production of gramophone records in unfilled plastic suitable for long playing records with silent surfaces, a project which has resulted in notable commercial success.

Lord Halsbury was a Member of the Advisory Council of the Committee of the Privy Council for Scientific and Industrial Research from 1949 to 1954. He has been Chairman of the Science Museum Advisory Council since 1951. He is also a Deputy Chairman of the Parliamentary and Scientific Committee and Chairman of the National Institute of Industrial Psychology.

Lord Halsbury is the grandson of the first Earl, who was three times Lord Chancellor and author of the legal classic, Halsbury's "Laws of England." He succeeded his father to the peerage in 1943.

A REVOLUTIONARY technical advance may be due to either of two types of cause: technical causes and economic causes. The first type occurs when a new technical process is found to be possible for the first time; such advances have occurred recently in the fields of the gas turbine, of the nuclear reactor and of chemotherapy. An advance of the second type occurs when a technical process which was always possible within the known bounds of nature's laws becomes profitable for the first time. The techniques we are considering at this Conference fall for consideration under both headings; there is in fact no single feature to which one can point and say "This is automation." For this reason, many are tempted to deny that the word stands for anything at all.

Historically, automation was coined as a nickname for the work of a development team at the factory of the Ford Motor Company in Detroit. This team was studying the intensive exploitation of what was known in orthodox jargon as "transfer machining." The project was in conception neither original nor epoch-making, but its inception represented some clear thinking by Ford's. As the sizes and cutting speeds of machine tools are increased, the capital charges they contribute to costs grow heavier and the incidence of idle time more onerous. In these circumstances the economic reward to be obtained by mechanically coupling the output of one machine to the input of another becomes larger in relation to the cost of the coupling. At a critical stage in the development of large fast cutting machine tools, a break-even point occurs. Before this point is reached, automation is uneconomic; thereafter it is profitable, and a new technical field presents itself to designers.

The sequel follows a familiar pattern. Designers crowd into the new field and develop everything from fundamental principles to gadgetry; the power of their method increases; the cost of doing what in the first place barely justified itself, decreases, its scope widens and there is an overflow of technique into adjacent fields. In control engineering terms there is a positive feedback. In human terms—nothing succeeds like success.

We are at present witnesses to the beginning of such an overflow. It is one component of the situation we are met here to discuss.

Control Engineering

A second component is associated with what is increasingly coming to be known as " control engineering." I do not know what to point to as the first automatic control device. The centrifugal governor of a steam engine (1778) must certainly rank as an early instance of automatic control. But similar devices had been used earlier than 1778 in flour mills. Thermostats, too, belong to the classified period. Automatic couplings between the sheets and tillers of model yachts were familiar to me as a boy. Control engineering is not new. However, there have recently been three groups of advances in this field which, taken together, add up to something which promises a revolution. The first group is associated with the development of measuring devices of the transducer type, and is a legacy from general physical research. To this group belong strain gauges, capacitor gauges, piezo-electric gauges, photosensitive devices, nuclear particle detectors and so on. The second group is associated with the intensive exploitation of the whole field of electronics, from its origin in the filament diode to its present climax in the transistor, and is a legacy from the radio, gramophone, television and telecommunication industries generally. It presents the control engineer with a range of devices capable of coupling any measuring device to any servo-mechanism by means of a suitable amplifier. The third group of developments lies in the field of servo-mechanisms and is a legacy of the cold war in the field of guided weapons. These developments have taken place not so much in design of hardware as in theoretical understanding, particularly in our understanding of the conditions controlling the stability of non-linear devices—devices of the " off or on " variety whose outputs are the inputs of control-servos.

A third component of the present situation is represented by a device taken from a neighbouring field to that of control engineering, namely, communication engineering. This device, a legacy of the pulse techniques developed for the purposes of radar, is known as the computer. You should not for our purposes here think of it as a mathematical device, so much as a coupling device like an amplifier. An amplifier couples a measuring device to a servo. A computer couples a group to a group ; complex pattern of input to complex pattern of output. This use of computers is still in its infancy, but already there exist machine tools coupled to computers such that the output of the tool follows instructions fed into a computer by its monitor. You will hear of such devices in the course of your Conference. Their intensive exploitation will transform the special purpose tool of today into the general purpose tool of tomorrow, the jigging of an automatic tool into the preparation of a computer input tape.

A fourth component of the currently impending advances in production engineering is represented by mechanised assembly. This development would appear to be in a less advanced stage than the other three. The fundamental problem is somewhat different and, with one exception, there is no technological advance to which one can point as a solution thereof. The spectrum of feasibility is wide. One can without too much difficulty visualise the automatic assembly of internal combustion engines for automobiles. Assembly of their upholstery and fittings is more difficult to visualise. I referred above to a single exception representing a technological novelty. Printed circuitry was what I had in mind. Printed circuitry associated with dip soldering techniques and hopper fed components does, in fact, permit some classes of electrical hardware to be manufactured without human intervention, save at inspection and control points.

One may only postulate this treatment for sub-assemblies however ; the analogy of the automobile should be borne in mind. One can visualise the automatic manufacture of electronic sub-assemblies designed for television sets without undue difficulty. Fitting the amplifier and the cathode ray tube into the cabinet, however, is not so easy to visualise.

Such then are the four component factors which enter into my concept of " automation "—transfer machining, control engineering, communication engineering and mechanical assembly. You will note that the first and fourth components may be mere extensions of what is meant by mechanisation, while the second and third involve eliminating the human operative from the feed-back loop and are qualitatively different. The first and fourth may accordingly eliminate muscles only. The second and third eliminate nerves and brains. A more puristic definition would insist on the presence of feed-back as a criterion permitting the use of the word " automation." I do not believe our subject gains anything by this restriction.

Social Developments

What will follow socially from the development of automation in the generation ahead of us ? Fears have been expressed that automation will lead to widespread unemployment. Are these fears justified ? How should managerial-man react to them as employer, as engineer, as economist, as representative of organised labour, or as politician ? We still have bitter collective memories of the unemployment of the 20's and 30's. This unemployment arose from monetary and economic causes. Must another social crisis develop out of technological causes ? Must the gifts of science, as so often before, carry a latent danger to be manifested in due course ?

Will organised labour take kindly to the new techniques, remembering the miseries, and they were real miseries, of the past ? Will Office Luddites of the late twentieth century smash up the computers that make them redundant ?

Historical Aspects

I will try to deal with the component parts of this problem in their proper order. First of all, however, let me dwell on its historical aspects in order to argue from a true perspective.

The world has endured two great periods of unemployment since the Industrial Revolution. They both derived from economic causes inherent in the deflationary consequences of the slump phase of what used to be called the trade cycle. The first period, the nineteenth century period of unemployment, was perhaps aggravated by the Industrial Revolution and the replacement of the labourer and the craftsman by the machine.

The second period, the twentieth century period of deflation, was also of economic origin. There was a boom after World War I, followed by a slump and a spurious recovery. A stock market crash on Wall Street in 1929 reinstituted slump conditions which were prolonged into the depression of the early 1930's. There was no technological component among the causes of the unemployment that resulted. There is thus no evidence that the rising productivity of the individual has ever caused unemployment, though it may have appeared to aggravate the unemployment consequent upon a classical slump.

Now, there is a great deal to be said for the view that in the recovery from the 1929 crisis the late President Roosevelt, basing his arguments upon the Keynsian theory of money, pioneered the world's way out of classical economic slumps. It could be argued that no slump will ever again be allowed to hold the world at its mercy, that we know the cure, and that we shall apply it if necessary. To know the cure is not, of course, to suspend the cause. We may have recessions ; they may be associated with transient dips in the employment graph ; they ought not to be prolonged. Analysts who study their incidence believe that early and accurate information with respect to the statistics of stock and work in progress should play a prime part in anticipating their onset. Since early and accurate information on such matters is expected to be at least one result of computerised accountancy, it follows that at least one component of the "Automation " which I have been discussing will certainly stabilise employment by helping to smooth out rather than exaggerate whatever remains of the classical " trade cycle."

The second historical aspect which I wish to introduce arises from comparing the population and industrial resources of England 100 years ago with those obtaining today. The population of today is nearly 52 million strong. A century ago, England was populated by only 27 million people at a much lower standard of living than that enjoyed by our contemporaries. It would probably be true to say that 100 years ago a population of 52 millions could not have been supported at all. No export trade attainable at that time could have fed 25 million additional mouths *and* paid for imported raw materials. Individual productivity was not high enough to have supported so artificial a situation. Inasmuch as these extra mouths can now be fed, technology has created employment beyond the dreams of a century gone by.

In economic matters I find it expedient first to think in monetary terms, secondly to translate those terms into technological realities, and thirdly to translate the technological terms back into monetary ones as a check ; one thus adheres closely to reality throughout the stages of any argument. Let me accordingly translate into technological terms what this creation of employment means. Consider a population of three individuals initially employed in subsistence agriculture, feeding themselves but no more, with the products of their labour. Let technology intervene in this situation. What results ? We find that one of them is thereafter growing food for three, another is making television sets for three and the last making tractors and machine tools, the means of production, for the other two and himself. That is the reality underlying any description we may give in monetary terms. In monetary terms, we say that productivity has increased, that wages have kept pace with productivity and that the farmer can, out of his wages or profits, afford a tractor for his farm and a television set for his home.

" Upgrading "

This process is sometimes referred to as " upgrading." We upgrade the agricultural labourers into tractor operators, engineers and electricians. This is only true if we interpret it statistically and socially. After a certain age you cannot upgrade an individual by turning him from a labourer into an engineer. You can, however, do what you please with his children and grandchildren. You can have as many engineers in the community as you please, provided there is a sufficiency of fathers employed at a level of productivity which will support their education.

There is, therefore, no reason whatever to suppose that automation will do other than what every previous technological advance has accomplished. It will enable us to support more people in this island and to support them with a higher standard of living, or to support the same number with relatively less effort, for a given increase in their standard of life.

Regarded socially, the extent to which automation will entail dislocation is therefore solely a matter of the speed at which it affects the community. Human beings commence their working careers at ages intermediate between leaving school (and completing military service) at the earliest, or completing a Ph.D. course (and military service) at the latest, that is to say, between an effective 18 and an effective 25.

If 20 be taken as a representative average, and the retiring age be taken as 65, then a human career-time occupies 45 years. Every year accordingly, 2.2% of the representatives of any profession or occupation retire and replacements for them have to be recruited. One cannot visualise automation causing an annual reduction in employment at anything like this speed. Nor can one visualise any analogous increase in the extra number of engineers trained in the exploitation of the new techniques. It therefore appears in the highest degree unlikely that any social change brought about by automation is likely to affect the structure of society to an extent that cannot be accommodated by the balance between retirement and recruitment, which is society's normal means of buffering a social change. It must also be remembered that only about one quarter of all those gainfully employed are engaged in manufacturing industries. Mining, agriculture, transport, office work and so on account for the majority. Thus only a minority will be at all affected by automation.

In brief, I can see no prospects of the type of short-term social revolution which disrupts a society. Insofar as our techniques are revolutionary, the revolution is in the technological approach to production. Insofar as they will affect society, the latter will undergo a process of evolution rather than of revolution.

So far I have been content to dispose of the social arguments against automation. I want next to consider some arguments in its favour.

What is the Use of Labour?

Let me be blunt as to the first. What is the use of labour? What are our hopes for it? If by labour is meant the hewing of wood, the drawing of water, the sweat in the fields and the dull routine of repetitive tasks, then I confess that I should like to see it disappear for ever from the face of the earth. Insofar as automation involves liberation from the drudgery of the office stool and the factory assembly line, then let us welcome it and rejoice in it, all of us with one accord. There is, however, another picture in which a nobler labour appears; let me draw attention to it explicitly, so as to excuse myself from any charge of depreciating labour in its dignity. Such is the labour of achievement where human muscles are still partly demanded for a high task: the work of the heavy gang, the construction camp, the lumber camp, and the oil rig; the raising of great works, of skyscrapers, bridges, dams and canals; the clearing of forests, the irrigation of deserts and the building of cities. These are still tasks for tough young men and it is my belief that tough young men will rejoice in the work of their hands directed to such ends, for many a long year to come. It is mere hypocrisy, however, to believe that tightening a bolt on an assembly line until the operator is dizzy partakes of the dignity of labour as I have portrayed it. It is equal hypocrisy to suppose that the dull repetitive arithmetic of a pay-roll is a worthy occupation for any member of a species that has produced Plato and Shakespeare, Newton and Einstein. If automation makes an end of these latter occupations, so much the better for automation. This is the first argument in its favour.

The Trading Situation

A second argument relates to our over-delicate trading situation. We have to import half our food and many of the raw materials for our manufactures. To do this we have to export one-fifth of our National Product. As this includes unexportable utilities and services, exports of manufactures need to attain a proportion somewhat higher than one-fifth. Forty per cent. of our engineering products need to be exported to help pay for our imports. These exports are not sold by decree. They have to be marketed in a competitive world. In the field of standard products we cannot compete against two classes of rival. Firstly, we cannot compete against those who are prepared to accept a lower standard of living than we enjoy. Secondly, we cannot compete against those who are prepared to accept a lower standard of leisure than we expect. Against such rivals we can only compete by trading in novelties and quality products not yet in the public domain. I do not underestimate the importance of these latter, but I must remark that we cannot live by them alone. They are important; they may be critically important by providing Mr. Micawber's sixpence, the margin that represents the difference between crisis and prosperity. A trading nation, however, is no different from a trading corporation. It needs must have a bread-and-butter business, today's profits from which will support the development of the novelties and quality products which will themselves provide the bread-and-butter business of tomorrow. And it is just because bread-and-butter business must of its very nature lie in the public domain that ours is at the mercy of the two classes of rival I have described above.

How can we defend our standard products, our automobiles and textiles, which sell for export in sterling units of a hundred million against the competition of our rivals? Only by technique, the technique of manufacture. Provided always that our standard products are made by more advanced techniques than are those of our competitors, we can compete by means of any combination of quality and price which will make them attractive to purchasers. This strategy, be it noted, is a possible one. A nation's standard of living is closely connected to its standard of education. A nation with a lower standard of living than ours, will enjoy, on the average, a lower standard of education. Techniques open to us will not be open to them through a dearth of personnel adequately qualified to operate them. A corollary to this truth is that we must constantly invest part of the annual increase in our national product in increased educational facilities. Failing this, we shall be emptying a pipe-line upon which our continued prosperity depends.

Automation is Essential

It is easy to fit automation into the foregoing picture. As a technique whereby standard products can be made and sold in competition with similar products marketed by our rivals, it is essential to the continued maintenance of our position in the world. It is essential to us and we cannot afford not to exploit it as intensively as we can.

I come now to a third argument in favour of its development. It is a domestic argument of a far-reaching character and one which may be unfamiliar to some of you. I refer to the statistics of our populalation and to the expected ageing of its cross-section over the generations to come. The great majority of those attending this lecture will be drawn from the professional classes and will be employed on pensionable terms. You will all have been saving for a greater or a lesser number of years to provide yourselves with a certain standard of living in your retirement. I believe that your hopes will tend to prove increasingly illusory. Your pensions have been calculated on the assumption that if the community can afford them in monetary terms, it will be able to afford them in real terms. As the average age of the population increases, as fewer and fewer young productive workers are left to support an increasing army of pensioners, this will be decreasingly true. You are kidding yourselves, the younger of you, if you believe that the pension rights which you imagine that you are accumulating will ever mature on the scale you have planned for. Your pensions will be paid, of course, but in an inflated currency caused by the rise in the price of productive workers in short supply. For inflation is the defence of the present against the past, of the young against the old, and of the debtor against his creditor. Only one factor can safeguard your future as pensioners against the fate of the creditor who has fallen into the hands of his debtor—an increase in individual productivity. Let the productivity of future generations rise, and your pensions can be paid at their real value. Remember this in your assessment of the importance of what we are met here to discuss—Automation.

An Important Social Aspect

May I now turn from these rather selfish considerations to a social aspect of Automation which is unlikely to attract much attention because it is essentially social and essentially negative. What of those who are *not* going to be upgraded because the technique of automation passes them by and leaves them unaffected?

I have referred above to two classes of labour. The labour of repetitive drudgery, on the one hand, and the labour of those engaged on creative tasks perpetually new because never repeated in the same time and place; Labours of Hercules if you will, but with an element of the heroic in them.

Mechanisation, automation, call it what you will, has relieved the former in the past and will relieve it progressively in the future. I do not believe the second stands in need of relief, but only of the high wages which all labour will command increasingly as productivity rises. If these were the only classes ot labour in the world, the world could foresee an end of the problem. There is, however, a third class of labour, a class destined to become increasingly isolated in the social sense and the psychological sense, as the members of the first class become converted into engineers and the members of the second acquire a more explicitly Herculean cast. This is the class of those whom the upgrading process has by-passed. Consider the coal miner and the stevedore. The one is engaged in the dirtiest, hardest and most dangerous occupation in the world. The other on the next most dangerous. In spite of all the applications of science to coal mining it remains the mining of coal. There is the same monotony entailed in a daily visit to the pit, the same sunless hours entombed therein, and the same lack of variety in much of the work waiting to be done. There is the same recurrent reminder of disaster somewhere on the road or, at the least, a bad accident round the next corner. And when all has been done, one ton of coal is just like another and disappears into the industrial unknown like all that have gone before it. Because the problem is specialised, because it is not our specialism, because we technologists have not yet been clever enough to solve it, let us not forget it.

May I tell you a story? I once visited a great fertiliser factory abroad. The works manager proudly explained to me that no human hand touched the product from first to last. From the delivery of the raw material to the conveyor delivering bags alongside the wharf or across it to a ship, everything was push-button control.

"May I look at that ship loading?" I asked.

"Certainly," he replied.

In the hold I found human labourers, each with a 1 cwt. sack of fertiliser on his back, carrying it from the conveyor which delivered it to a far corner of the dimly lit hold where it was stacked.

"These, of course, are not our employees," my host explained. "They are casual labourers engaged by the wharfingers." He was of course speaking the truth. The casuals were not his responsibility. Whose were they? No-one's! That is one way of saying that they are everyone's. The problem is a real one. A ship is not a standard product. Holds are not a standard shape. They may indeed be of a very awkward shape. They may contain obstacles—ribs, pipes, and so on. How robot handling machines could be made to work in them is not easy to visualise. The Martians of H. G. Well's fantasy had them well developed and yet it seems that we have not. Or have we? How far away are we from the robot? We have developed hydraulic joints for the legs of aeroplanes; would a robot's arm and fingers differ from them by very much? We have a wealth of transducers available in the laboratories of the physicists; could they not be his receptor nerves? We can already think in terms of miniaturised computers based upon transistors and magnetic core logical elements: his central nervous system and rudimentary intelligence! Our increasing knowledge in the field of servos—could it not provide a basis for his effector nerves?

The Most Human Problem

There is a problem for you. The most human problem in the automatic factory: the problem of the one toiling human left over after the factory has been automatised.

Be clear where we shall arrive if we do not solve this problem somehow. Marx and Engels visualised a world of slaves supporting a handful of expropriators. The course of history appears unlikely to verify this prediction. Technology appears more likely to leave us with a cross-grained minority of those on whom has fallen the world's residual drudgery in a majority world of engineers, administrators, scientists and artists; cross-grained because psychologically isolated from and therefore at cross purposes with the rest of the community.

Human beings are tied to one another by links which are emotional in various degrees and of a quality ranging from conscious to unconscious. These links are dynamic and multi-dimensional. Each individual is linked to many neighbours in many different ways. A social sub-group arises when the ties between its members are stronger than or qualitatively different from those between their neighbours. Sub-groups are linked to form larger units and these in turn form national units. Sub-groups tend towards isolation when the Intra group and Extra group ties are strengthened relative to the Inter group ties. The task of the social engineer is to strengthen Inter group ties at the expense of Extra group and Intra group ties; his goal is to diminish group isolation and to increase the uniformity of interaction. A serious situation arises for him when the social and psychological isolation of a sub-group within the community is in over-marked contrast to its economic or political interaction herewith. We say of the members of such a group "We cannot get along with them, and we cannot get along without them."

Comradeship in hardship, danger or misfortune is the basis for a strong unconscious emotional tie between those who experience it. An army of soldiers readily forms a sub-group on this basis; if it becomes unduly isolated from the rest of the community it may break loose altogether and become a danger to the nation. We experienced this in Cromwell's day. Much of our constitutional legislation is directed to ensuring that the experience is not repeated by providing for the subordination of the military to the civilian authority.

The social-psychological situation of the coal miners is not dissimilar. Our community is highly dependent on them functionally, but isolated from them psychologically ; they enjoy an emotional bond, based on companionship in hardship and danger which in that particular dimension of social linkage ties them together as a sub-group more closely than we, their neighbours, are tied to one another. The automony they require for themselves on the psychological plane is thus in sharp contrast to the co-operation which we require of them on the functional plane. The situation is not without political and social dangers.

In crisis or in war, they become more closely knit to the community, not by any change in them but by a change in us. When *we* experience hardship or danger, we are more acceptable to them ; from their point of view we are more human.

Thus psychological and social unity is promoted by anything that makes their lives less hard and dangerous or our lives more so. Isolation and division are correspondingly increased by anything that makes our lives easier and safer or theirs less so. What is important in this context is relative change, not the absolute nature of our respective ways of life.

Insofar as automation will upgrade some and pass others by, it will be to that extent a factor making for disunity. The mining community may be one such group by-passed by the change. I have only mentioned them for purposes of illustration. There will be other such groupings and the problems will be the same for all. Let us not forget it therefore when considering technical and human problems of the automatic factory. For the greater problem is that we shall fail in technique or humanity and leave the task but half accomplished.

If we can bear that problem in mind throughout our developments then, in the end, all will be well.

MARGATE CONFERENCE

DISCUSSION GROUP 1D

THE ENGINEER AND THE AUTOMATIC FACTORY– A CHALLENGE TO THE TECHNICAL COLLEGE

by C. L. OLD, B.Sc.(Eng.), A.C.G.I., M.Sc.(Tech.), M.Inst.C.E., M.I.Mech.E., M.I.Prod.E., A.F.R.Ae.S.

Principal Old

Principal Old served his apprenticeship with the London & North-Western Railway Company at Wolverton, and then went on to the City & Guilds of London College, where he graduated with honours.

He then joined Saunders-Roe at Cowes and spent several years in the design office. He was appointed to the staff of the Department of Mechanical Engineering at the College of Technology, Manchester, with a similar position in the University.

At the outbreak of the Second World War, Principal Old returned to aeronautical work at the Royal Aircraft Establishment, Farnborough, where he specialised in various aspects of airframe structures. In 1945 he was appointed Vice-Principal of the Royal Aeronautical Technical College; in 1948, Principal of the Rotherham College of Technology; and in 1951, to his present appointment as Principal of the Wolverhampton & Staffordshire Technical College.

He is Chairman of the Wolverhampton Section of the Institution, and is a past Chairman of the Education Committee.

THE sub-title of this Paper might well be: "The contribution which technical colleges can make to the provision of suitable and sufficient man power for the second industrial revolution." The specific reference for the Conference is the Automatic Factory, but it would be quite wrong for us to think of training men for a narrow field of occupation and worse still to train them apart from educating them.

The Automatic Factory is no more than a symptom of the greatly accelerating industrial development which we can expect to see take place within the 25 years of the Chancellor's prophecy. There will be many other important and related developments for which man power of the same calibre will be required. It is, therefore, much more appropriate to consider the pattern of development which constitutes the challenge to the technical colleges rather than the narrower challenge from the Automatic Factory alone. Automation itself is not the challenge, because technically automation is no more than the bringing together of certain techniques such as electronic controls, specialised machine tool unit operation and planned maintenance for a specific purpose, although there may well be certain specialised techniques requiring special treatment.

There is always the overriding consideration in education and training schemes that we must avoid producing the robot type of individual; always it must be remembered that the purpose of industrialisation must be to serve man and to avoid—positively to avoid—man becoming the slave of the machine. It is not an absurd fancy that having set the machines going man may forget the purpose for which the machines were designed and continue to feed them as though feeding them were an end in itself. The writer of the book called " Metropolis " had this idea in mind many years ago, and it must be remembered that our task is first to produce men and, secondly, to endow them with specialised knowledge and skills which are the means by which they live and not the ends for which they live. There appears to be an urge inherent in man towards greater freedom. Oriental man satisfies this urge by more and more mastering himself as by eliminating his desires and appetites, whereas Western man seeks the same satisfaction by mastering things—mainly material things—and here lies the danger.

The Nation's Ambition

It is worth while looking at the shape of the great industrialisation process which is ahead of us as it gradually takes shape through the pronouncements of Government departments, nationalised industries and private enterprise. Many of these projects are inter-related so that they constitute different facets of the same thing. Overall, the national ambition runs to enormous developments in the next decade or two.

The Central Electricity Authority has plans for expending £1,200 millions in the next 10 years on power station development, including £300 millions for nuclear power stations, a figure which is perhaps quite reasonable, bearing in mind that our consumption of electricity has gone up by 7% per year, for many years now, which means a doubling of consumption every ten years.

The Government has announced a big road building programme, a £1,200 millions development programme for the railways, and a large capitalisation is taking place in the mining industry.

Private industry is busy doubling the output of motor vehicles and, over and above all this, an unprecedented defence programme including hydrogen bomb production is in operation.

All political parties are committed to extended social services, to hospital and school buildings and other developments, including technical colleges.

And, finally, the Chancellor of the Exchequer, at the conference of the Conservative Party at Blackpool in October last, used words which have since become famous. In the course of his " investment in success speech " he said:

> " I see no reason why, in the next quarter of a century, if we run our policy properly and soundly, we should not double our standard of living."

Taken as a whole, this is a fantastic programme but every aspect of it reduces to one common factor —the application of more and more scientific and technical knowledge, and this really means—in its applications in industry—knowledge of an engineering type and therefore men trained as engineers.

The definition of an engineer recently used by Sir Ewart Smith may help here to clarify our final objective.

> " A professional engineer is competent, by virtue of his fundamental education and training, to apply the scientific method and outlook to the analysis and solution of engineering problems. He is able to assume personal responsibility for the development and application of engineering science and knowledge, notably in research, design, construction, manufacture, superintending work, managing, and in the education of the engineer. His work is predominantly intellectual and varied and not of a routine manual or physical character. It requires the exercise of original thought and judgement and the ability to supervise the technical and administrative work of others."

There is already a great shortage of men of this type and this shortage—relative to the demand—will increase, unless active steps are taken to develop every single individual in the community to his highest possible potential at whatever level that may be. It is not merely a question of helping people to get better jobs—that phase is long past—it is a national necessity that each should be trained to the utmost.

An examination of two trends in related factors emphasises how serious a problem it is which faces the nation. The first trend concerns population and the second the trend in quantity of technological training being carried out in the U.S.A. If it were possible to analyse trends in some other countries such as the U.S.S.R., the result might be even more salutary.

Population Trends

The matter of population is examined very carefully and in great detail in the Report of the Royal Commission on Population published last year. Taking everything into account that is at present foreseeable, the Report states:—

> (i) Total numbers will continue to grow in the near future, perhaps even for a generation.

The growth will not be rapid, and the further addition to the population which can be expected is not large.

(ii) The population of working age will remain about its present size for at least the next 30 years, though it will come to form a somewhat smaller proportion of the total.

(iii) The population of young adults (15-39) will show a fall of about 1·4 millions in the next 15 years.

(iv) The number of old people (over 65) will grow steadily over the next 30 years, the increase amounting to at least 2·3 millions and very probably more. The proportion of old people to the total will increase considerably.

This matter is illustrated graphically by Figs. 1, 2 and 3, taken from the Royal Commission Report. Fig. 1 shows the age pyramids for the years 1891 and 1947. A comparison of the two shows the effects of great economic disturbance, two World Wars and the impact of artificial methods of birth restriction. For present purposes it is the trough shown between the age range " birth to 39 years " which is disturbing. The trough is moving forward into that portion of the population from which the nation's greatest output of material goods and of ideas should come.

Fig. 2 illustrates the same point in a slightly different form. Both suggest that the trough is being followed by a rise or bulge, which in this year 1955 is just entering the secondary school stage, but it is not a continuing one and Fig. 3—which is necessarily somewhat speculative—indicates trends on three alternative assumptions. It is not, of course, the absolute number of births at any time which determines trends but the rate of reproduction, or in other words the size of family.

Series (a) on Fig. 3 results from assuming family size to remain, for the future, as it is for couples married between the years 1927-1938.

Series (b) is based on a full replacement rate of birth and settles out at a birth rate of rather more than 700,000 as compared with well over a million at the turn of the century.

Series (c) shows the catastrophic fall by the early years of the next century if the present family size falls to no lower than 80% of the present size, a quite likely possibility.

A glance at the 260 pages of the Commission's Report will show that the factors affecting population are many and varied, but the main conclusion remains—only by the utmost use of all the powers

CHART I

Age Pyramids for Great Britain, 1891 and 1947

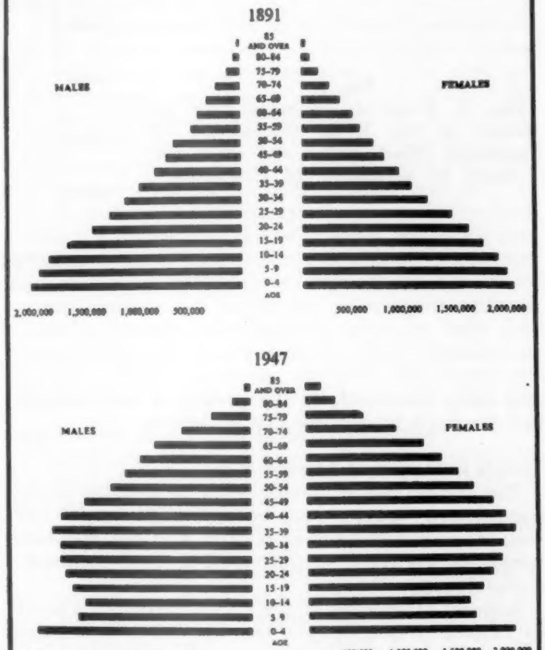


Fig. 1

CHART II

Population of Great Britain by age, 1947, compared with a "normal" age-distribution

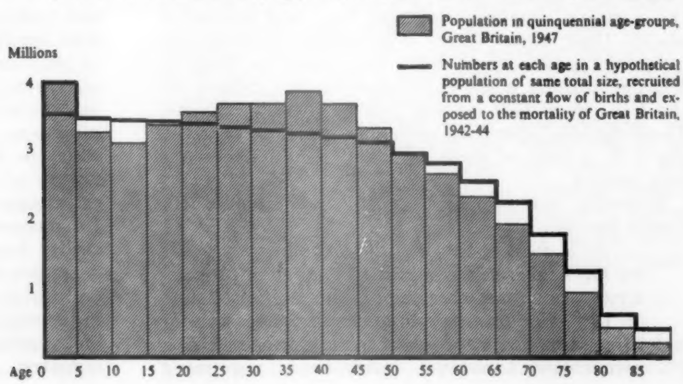
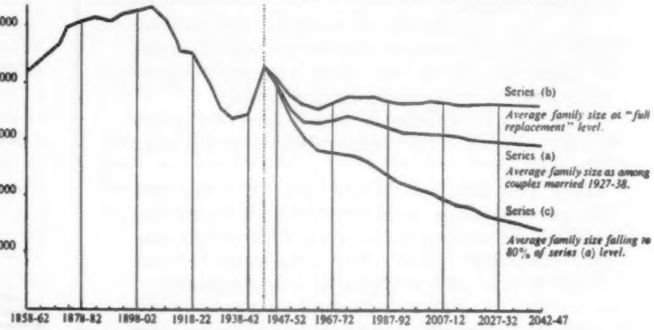


Fig. 2

Fig. 3.
(Figs. 1, 2 and 3 are taken from the Report of the Royal Commission on Population (Cmd 7695) and are reproduced by permission of H.M.S.O.)

CHART III Annual Births, Great Britain, 1858-1947 and as projected, 1947-2047 on three alternative assumptions about the size of families in future



NOTE.—In each case future marriage-rates are assumed to be intermediate in effect between the marriage-rates of men and women in 1942-47, mortality-rates are assumed to decline from 1947 to 1977 at approximately the same rates as over the last 50 years, and net migration is assumed to be nil.

and skills possessed by the people of this country can we hope to achieve our ambitions.

Trends in Output of Trained Men

The second related factor—related because of the competitive element and because so much of our way of life is measured in relative and not absolute terms—is the trend in output of trained engineers in the U.S.A.

Reports of training in the U.S.A. have come to us by various routes, but the two which will best serve our purpose are the Anglo-American Council on Productivity Reports on Education for Management and Universities and Industry, and the work of Sir Ewart Smith in comparing trends in Great Britain and the U.S.A. Both of these sources have been available for some time but their conclusions are still valid and, indeed, become more pertinent in the light of the population trends already referred to.

The gist of Sir Ewart's argument was that to double or treble our output of trained men was in itself meaningless and that only by a steadily increasing output could we meet our obligations. He showed that the curves of industrial output in Great Britain and the U.S.A. were of the same shape in the two countries taken separately, as their respective outputs of trained men. Putting specific values to the curves of the two countries, they had crossed in about 1890, since when U.S. output of men and industrial goods have both increased by roughly 3% per annum, while the corresponding figures for the U.K. were 1½% or just half of the U.S. figures. These figures, operating over the years, have given the U.S. a lead of some two and a half times our own output.

Recently commenting on his own theme, Sir Ewart has said:

> "It is good to know that in the last six years we have increased our rate of change of productivity; not, it is true, along the suggested line of 10% per annum, but certainly to two or three times our pre-war average rate. On a percentage basis we have been improving rather faster than the Americans during the past six years, but I stress that unless our percentage rate of increase is double theirs, we are not on the way to catching them."

The Anglo-American Reports both point the same lesson. After making the point that the American first degree is of a standard comparable with our own Higher National Certificate in at least its technical content, the Report on Universities and Industry goes on to say:

> "In Great Britain the total number of degrees, Higher National Certificates and Higher National Diplomas awarded in science and technology in 1949 was of the order of 14,000. The number of degrees in science and technology awarded in America in the same year was approximately 110,000. It would appear, therefore, that when allowance is made for the difference in size of the labour force in the two countries, America is employing nearly three times as many persons educated in technology to this comparable level as in Great Britain."

Contribution of Universities

The output of scientists and engineers in Great Britain is mainly from the technical colleges and the universities. The university output of graduates has doubled since the War, but not the output of 1st class honours graduates : in other words, we have not been able to double our output at the highest level of the universities, a fact of some significance. It is, of course, inherent in a university that its intake must be restricted by the very nature of its matriculation tests and the type of experience it offers to its undergraduate population. Its matriculation test is essentially one of verbal ability based on the kind of work so well done by grammar schools and, in admitting students, relatively little attention is paid to other human attributes which play an important part in a man's later life, particularly if that later life be spent in industry.

A university course of training is arduous and is aimed at developing a full man able to achieve an integrated philosophy of life; able to make right judgements, although the evidence is not complete, and to achieve a result which is proper to its context. Its products should have breadth and be able to relate their own activities to human activities generally.

Although a man may satisfy the first requirement, that is, the academic one, he may not be temperamentally suited to reap the full benefit of the second.

Application of the dual test of academic achievment and personal qualities is bound to be restrictive on entry to the universities, and it is not to be deplored that this should be so. The universities must not lower their high standards merely in answer to the call for numbers.

Sir Henry Tizard, writing in the May issue of "Research" says in commenting on the massive increase in provision at the Imperial College of Science and Technology :

> "Many people must be wondering, as I am, where these greatly increased numbers of university students of technology of the highest quality are to come from. Of one thing I feel sure, namely, the universities will not be able to produce many more men capable of dealing with circumstances for which there is no direct precedent in industry without diverting the interests of many young men from pure science and other subjects":

and later

> "But don't let us forget that the majority of engineers in industry benefit by a more practical training than a university affords, as John Hopkinson said."

Further, there will always be some people for whom a university course would be suitable but who, for various reasons, do not, in fact, proceed to the university.

Bearing all these factors in mind, it is highly probable that the universities have reached their useful limit of expansion and that any further expansion of higher technological training has got to take place in the larger and better equipped technical colleges.

Contribution of the Technical Colleges

Already the major colleges are making a big contribution at the highest level through the London external degree. In 1952, 1,693 University of London Degrees were awarded in Science and Technology to students from 74 Technical Colleges. Between 1945 and 1949, 218 higher degrees were obtained.

The Ministry of Education Report for 1952-3 shows that 4,736 full-time, 6,433 part-time day students were taking university degree courses in technical colleges and 6,140 full-time and 26,098 part-time day students taking comparable courses not directed to university degrees. The grand total of these figures is about 43,000 which may be set against the number of students in faculties of science, technology and agriculture of about 30,000.

These facts are related not to justify the inclusion of degree courses as such in technical colleges, but to indicate that some colleges are already staffed and equipped for work at the highest recognised levels.

The biggest contribution of technical colleges, in terms of sheer numbers, is through the Higher National Certificate schemes, which began with the "Mechanicals" scheme in 1923. In 1954, 3,072 Higher Certificates were awarded in Mechanical Engineering and 2,013 in Electrical Engineering.

In recent years, 60% of the new members of the Institution of Mechanical Engineers, and 40% of the Institution of Electrical Engineers, have been Higher National Certificate holders, while the proportion in this Institution must have been even higher. This is evidence that there are many young men who are capable of following an arduous course of study, continuously over at least five years, and have the necessary personal qualities to persist. Their value in industry has been immeasurable.

Weaknesses of National Certificate Courses

There are, however, two particular weaknesses in National Certificate schemes, in the light of modern requirements :—

(i) a lack of the physical sciences and insufficient mathematics;

(ii) a lack of breadth within the course of study and, due to the restrictive nature of the course, which is a part-time one, little—if any—development of imagination.

There is no answer within the present scheme to the problem posed by (i) and yet practically all recent developments in industry stem from the exploitation of basic knowledge and most have been the work of men trained with a sound understanding of scientific principles—conveniently classified by the schoolmen as chemistry, physics and, to some extent, biology and mathematics.

A partial answer is being found to the problem set by (ii), namely, the lack of breadth, but it involves five years of study beyond the Higher National Certificate for its completion. It is in the courses of management studies provided by some colleges, in which the basis of studies is really no more than a broadening of the outlook of the technologist in such matters as the historical development of industry, economics, elements of such things as personnel management and the meaning of accounts. The courses cannot produce managers; they can only help a man already trained as an engineer, or some other specialist, to an understanding of the requirements of a manager—to an appreciation of what he will see within the wider horizons he is bound to observe by virtue of the fact that he is standing on a more elevated station. Many part-time students will still have to travel the long way, but, for the best, the nation must have them trained more quickly and made available for useful work.

The School System

The engineers and scientists who eventually find their way into industry, whether by the university

or technical college route, will have passed through the same initial stages in their earlier education. For the bulk of the nation's children this means primary school to the age of eleven followed by entry into grammar, technical or modern school according to whichever of these best suits the child's abilities and aptitudes and is in accordance with the wishes of his parents.

This is a very neat theoretical arrangement and broadly speaking it has worked reasonably well as far as the grammar school stream is concerned. Technical schools are still too small in numbers to have begun to count and the modern school has received whatever may be left over from the selection for grammar school places. Accepting the basic assumptions of the 1944 Act, it should be as important to take positive action to sort for technical and modern school streams as for the grammar stream. The present system of working is only satisfactory as a whole if it is admitted that admission to the grammar school is based on verbal and academic ability, quite irrespective of other abilities and aptitudes and such character-forming factors as the child's home. In other words, the sorting and hence the current meaning of ability is on a purely intellectual basis and is a test of the child's ability to follow the type of course so well dealt with by the grammar schools. And yet final and ultimate success in any career depends upon temperament, perseverance, imagination and breadth of outlook in the man, which, whilst it cannot be attained without knowledge and some academic ability, is not synonymous with either. In addition, of course, there are all the moral qualities of integrity, loyalty, sincerity and so on which go to the making of the man who can be entrusted with responsibility. All that is necessary for the present purpose is to realise that these qualities are not taken into account in the sorting at eleven plus except, perhaps, in a few border line cases, and hence this vast reservoir of human potentiality may never enter the grammar school—and subsequently the university.

The first large group of students who will come forward into further education then will be the modern school leavers—leaving generally at the age of 15 and in due course when the leaving age is again raised, at 16 years, and possessing verbal ability in general of a lower level than the grammar school type but with other qualities in plenty. They will not enter the technical college directly, but will need to pass through several years of a college of further education which will act as a contributory institution to the technical college. In any case, the county college portion of the 1944 Act will probably be implemented well within the twenty-five years under consideration and then all young people between school leaving and the age of eighteen will be required to attend a college of further education on one day per week.

The quality in technical and general subjects of boys and girls leaving secondary technical schools is usually high, and if their courses have been worked out in conjunction with the technical college, instead of slavishly following a grammar school pattern, their number among the best students of the college is likely to be high.

The grammar school group is an interesting one, for it will contain those best able to achieve academic standards and, in general, those who will pass on to the university. But it will also contain a large number who for various reasons will not go on to the university.

The F.B.I. has recently published a very useful little report on "Public Schools and Grammar School Boys in Industry."

It says :

> "In the grammar schools, the leaving age extends from fifteen to nineteen, with 18% (probably a temporary high figure) of the boys leaving at fifteen, 48% at sixteen, 34% at seventeen to nineteen. Excluding those boys who are destined for the university and may possibly enter industry later, a large proportion of the school leavers are therefore available for recruitment at ages when industry is in direct competition with the Civil Service and other professions. The same is true of the Public School boy who leaves at eighteen or nineteen."

From the grammar and public schools may come boys of good calibre at sixteen or eighteen years of age corresponding with the General Certificate of Education at Ordinary or Advanced levels.

The pattern of school leaving, especially from the grammar schools may, and should, change in the direction of more boys remaining at school until the age of 18. In 1954 the Ministry of Education published a report on Early Leaving and among their conclusions the investigators state :—

> "We have made a qualitative study of the field of capacity for sixth form work, and have concluded that from the grammar schools intake of 1946, in addition to about 10,000 boys and 7,000 girls who took advanced sixth form courses, there were about 5,000 boys and 5,000 girls who had the capacity to do so if they had stayed longer at school. Of these about 2,900 boys and 1,300 girls would have been suited for courses in mathematics and science.
>
> "If all these boys and girls had completed advanced courses, the number of boys who in fact did so would have been increased by about half and the number of girls by about two thirds. There could also have been a substantial increase, which we cannot estimate closely, in the number of boys and girls taking general sixth form courses. But it seems likely that less than half of the present intake into grammar schools could profitably take sixth form courses.
>
> "We acknowledge that some of those who have the intellectual capacity for sixth form work may be right to leave without undertaking it. By the time they are 16 they may have so far lost the taste for school life that they may do better to finish their education elsewhere or to return to it later. We believe, however, that these are a minority.

"At present there is a great national need for scientists of many kinds. There is no reason to think that this need will decline or to doubt that all the scientists of good quality that the schools can produce can be profitably absorbed, if the universities and major technical colleges can play their part. The problem remains of providing the necessary scientific staff for the schools, but if this can be solved the 4,200 potential scientists out of the additional 10,000 boys and girls who could well take advanced courses should have no difficulty in finding suitable occupations.

"The number of boys and girls who now leave at 15 and would do well to stay on for another year is obviously very large. It will not include all the boys and girls (amounting to 7,000 boys and 9,000 girls in the year of our sample) who now leave grammar schools without completing a five-year course, for some of these are misfits who are right to leave; but it will include substantial numbers of boys and girls who do not go to grammar schools at all.

"Indeed, the whole of our argument about selection makes it necessary to entertain the possibility that there may be considerable numbers of boys and girls in modern schools who must be regarded as premature leavers, just as much as their counterparts in grammar schools."

It can confidently be expected that many of the implications of this Report will be accomplished facts well within the next twenty-five years.

To summarise, the ages and levels of attainment at which young people will enter technical colleges are :

(a) from the grammar school, students of eighteen who have completed sixth form courses in science, and others of sixteen who will have completed fifth form courses and probably have obtained general certificates at ordinary level in science and mathematics with supporting subjects such as English and a foreign language.

(b) from the secondary technical school, similar to the output from grammar schools but in addition further pupils may be expected who will have completed courses in engineering and will leave at both sixth and fifth form level.

All of these may well enter a major technical college directly.

(c) from the modern schools and passing through colleges of further education first, will come the largest group, some with high academic ability, but most, able to become first class craftsmen and/or foremen and perhaps under managers.

Future Development of Courses in Technical Colleges

The pattern of courses in colleges will have to cater for these varying degrees of ability and development and will probably be similiar to that which holds today, except that the day load by way of day release from industry and full-time and sandwich type courses will be larger. National Certificate courses will still constitute a large but smaller proportion of activity and provide a means of entry to sandwich courses, and craft types of courses will continue although probably modified to suit new conditions.

Sandwich Courses

The highest level course, apart from post advanced and research work, is likely to be the sandwich type, in which substantial periods are given full time, alternately to education and industrial training, the standard finally achieved being governed by entry standard and the period of duration of the course. To be of real value in industry, the final standard has to be equivalent to that of present university first degrees, although rather different in kind.

The academic level at entry should be of the order of ordinary National Certificate or General Certificate of Education (advanced level). These two alternative entry conditions will allow recruitment from two distinct sources, but from either stream the recruitment must be a joint operation between the employer and the college, for academic attainment must not be the only criterion. There is plenty of ability in other than the academic sense. A combination of aptitude, ability and personal qualities is much more important to high responsibility in industry than high academic ability alone. From the National Certificate stream will come students already tested in part-time study and with several years of industrial experience. From the G.C.E. stream will come boys with a good grounding in science and the other qualities which VIth form grammar school education develops. Both groups will be aged about 18 years at entry and each will teach the other a good deal during their years of study together.

The other factor governing final standard is duration of the course. To give the same general coverage as a degree course and to allow sufficient time for adequate practical training in the works, the minimum time would appear to be four years, giving 24 months of study—equivalent to rather more than three full academic years at a university. (Fig. 4.)

The first three years would probably qualify for an award of the type now known as the Higher National Diploma and a fourth year would qualify for a college associateship, or probably whatever new national award may become available, and would carry full professional status.

The aim of the course will be to give a sound basic training in science subjects, followed by the usual engineering subjects such as strength of materials, mechanisms, fluid flow including heat transfer and thermodynamics, work study, machine tool operation and electricity with mathematics, engineering drawing and English studies running right through the course. The second, third and fourth years would increasingly specialise in mechanical, electrical or production engineering and aim at the full examination requirements for Associate Membership of at least one of the professional engineering bodies. A good deal of the

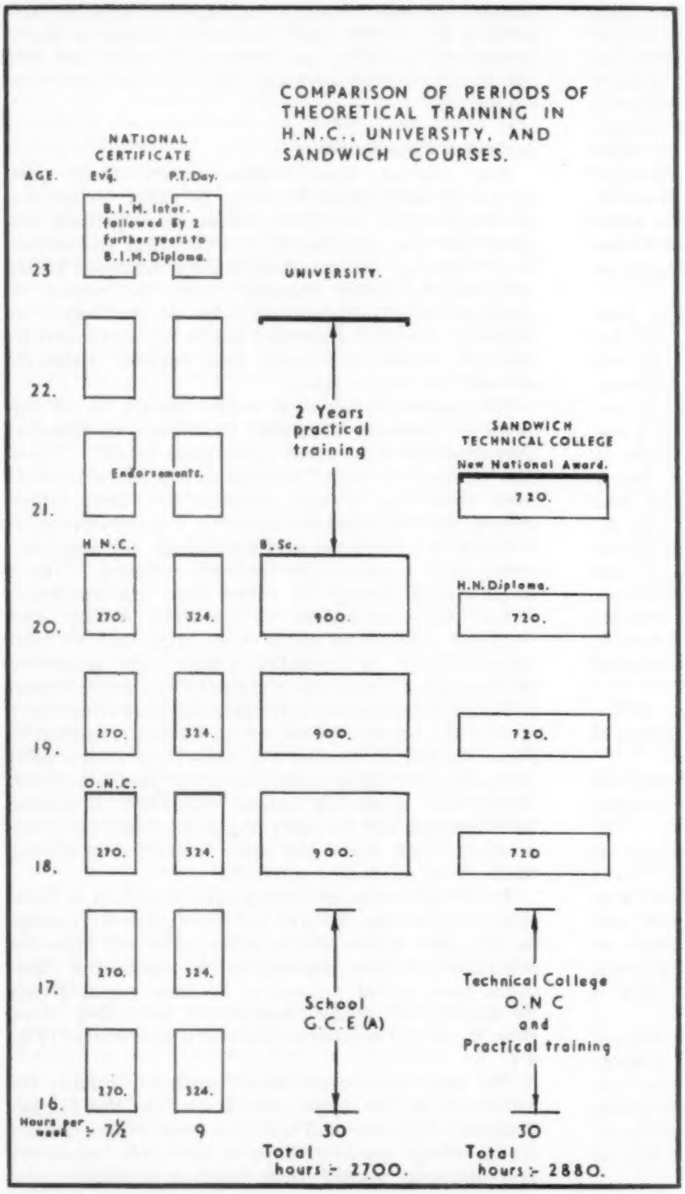


Fig. 4.

work in the final year would be done by means of projects which would synthesise the subjects previously dealt with individually. The English studies would, in reality, look after such broadening in education as a good technologist or manager would require.

Not every college is going to be able to offer such courses, for obviously not only must first-class provision be made for the subjects directly studied, but good provision must be made in those aspects of learning which are supporting the main work, such as the sciences and in some measure the humanities.

The College must be broadly based in terms of subjects covered. All students of engineering for example should be well supported in such ancillary subjects as physics, chemistry, mathematics, metallurgy and English, and of course there must be a well-equipped library and laboratories and qualified staff.

There should be an active student body in the college which could do much to develop the personal qualities of students, and hostel accommodation should be available wherever possible.

The sandwich course appears to be the most effective way of increasing the output of good tech-

nologists at a greatly accelerated rate.

There is a tendency to say that suitable candidates are not available for this course, but industry must take its courage in its hands and give some of the better Ordinary National Certificate students a trial, for experience shows that, in any case, they will occupy positions of trust and responsibility. Managers always have been obtained, and nearly always from the men who have climbed the industrial ladder.

The supply of trained people will be increased by providing a proper entry to industry for the increasing number of boys who remain in grammar and technical schools to 17 or 18 years of age. Industry must take more active steps in local schools to let the prospects offered to VIth form pupils by this form of training be better known.

The day-a-week release which has become standard practice has paid dividends through the increased number of Higher National Certificate winners—5,000 in 1954 in mechanical and electrical engineering alone—and now the time is ripe for the next step forward, to ensure that the right kind of men are available at the right time and in the right places to meet the demands of the future including the demands of the automatic factory.

National Certificate Courses

National Certificate courses have been in operation, and with increasing success, since 1923. The running total of mechanical engineering awards by 1954 was 37,141. One of the principal reasons for the high success of National Certificate schemes has been their support by the professional engineering bodies. It might almost be said that the success of the scheme is becoming an embarrassment to those bodies and there is now a tendency which may well develop not to recognise that a Higher National Certificate will give such a large measure of exemption as in the past. Ultimately it may be that membership of the major institutions and hence professional status will be confined to those engineers who have obtained a university degree or qualified through a recognised sandwich course. Should this come about or even the tendency develop National Certificates will take on a different look and, of course, their function will change. If only degrees and sandwich courses qualify for full professional status, then training in technology will indeed become tripartite, and the output of teaching institutions will be in terms of technologists, technicians and craftsmen, representing a victory for those who have advocated this division for some time, and making of the National Certificate course a training for technicianship. To meet this purpose the standard of mathematics could be reduced and the approach become more practical, with the emphasis of the course as a whole changing from the design function to the draughtsman designer, who has a greater knowledge of the physical properties of all kinds of materials and of workshop processes. He would need also to be a competent draughtsman, which would mean a revival of the subject known as machine design which has tended to fade out of college curricula in recent years. The more abstract calculations of a design would be passed on to either a mathematician or a technologist.

The second principal function for which training as a technician would be appropriate is in the field of planning production and machine maintenance. This function would be particularly important in an automatic factory and would obviously call for a knowledge—not as profound as that of the technologist—of such modern aids as electronic devices and servo-mechanisms.

The greater complexity of all these devices will require a select group of men who are of approximately Higher National Certificate level, but who also retain and develop their skills as craftsmen. Men who remain very much available for skilled work requiring a fairly deep understanding but who, unlike the present Higher National Certificate holders who pass on to office work, will remain available in super maintenance and development departments.

The third type, namely the craftsman, will be required just as he is today. No matter how fully developed automatic factories and other aspects of the Second Industrial Revolution may become, it will always be essential to have the men who can make the parts of the machines which make the consumer goods. All that really happens as industrialisation proceeds is that the skilled man is removed further and further from the finished product, but always he is in the train of events somewhere. For this man there may not be much change in training from the present pattern, other than in a more intense and less diffuse training. Already many larger industrial firms have set up their own training shops in which the elements of craft training are dealt with intensively, as against the older system whereby an apprentice picked up what he could from a skilled man who might or might not take a genuine interest in his training. For the smaller firms unable to maintain training shops, it is probable that the medium size technical colleges will have to provide this facility.

There is one other important way in which the technical college will need to meet the challenge of the future—it is by the further development of its system of short and post-advanced courses. Short courses are designed to give instruction to a selected group of people in a specialised technique as, for example, Work Study. The short course is a very useful medium for adding to the knowledge of those already trained but for whom a specialised knowledge is desirable.

The post-advanced course is also designed for the man already trained and is intended to survey the latest developments in some advanced branch of knowledge as, for instance, " Heat Transfer ". It is most likely to call for a thorough understanding of the subject to date, and the post-advanced course will take into account recent researches and the developments taking place in the particular field.

It may be assumed that any colleges engaged in advanced teaching will have active schools of research particularly applicable to industry. Indeed, the college should so gain the respect of

industry, that industry will automatically turn to it for aid in the solution of problems not of a routine nature. For example, a firm mainly concerned with mechanical engineering is suddenly confronted by a problem involving a deep knowledge of chemistry. Either the firm could appoint its own chemistry staff or consult the college. Thus will colleges and industry be drawn closer together and earn respect each for the other. Such a relationship will enable a much more fruitful interchange of staff than at present exists between industry and the colleges with far reaching results all round.

In conclusion, it would appear that the present pattern of technical colleges is likely to persist but with some quite considerable changes in emphasis, especially in the most advanced and National Certificate fields. A certain amount of elasticity will have to be introduced in preparing new and modified courses according to the needs of local industry. The colleges and industry will need to draw closer together in order to work out co-ordinated forms of training—a step which will be facilitated by the many appointments of training officers to industrial firms, many of whom are genuinely interested in educational problems. Thus we can confidently expect a suitable and adequate supply of men of the right calibre for the enormous tasks that are ahead.

Bibliography

A programme of Nuclear Power
Presented to Parliament, Feb. 1955. Cmd. 9389.

Report of Royal Commission on Population
Presented to Parliament, June 1949. Cmd. 7695.

Productivity Report on Education for Management
Anglo-American Council on Productivity.

Productivity Report on Universities and Industry
Anglo-American Council on Productivity.

Report of the Central Advisory Council for Education.
"Early Leaving"

F.B.I. Public School and Grammar School boys in Industry.

Report on the Supply of Students from Secondary Grammar Schools for Higher Technological and Scientific Education.
Memorandum prepared by the Universities Advisory Committee of the Association of Scientific Workers.

An interim report on Courses for Electrical Technicians. I.E.E.

Report of the Technical Colleges and Industry Conferences. F.B.I.

MARGATE CONFERENCE

DISCUSSION GROUP 1E

THE AUTOMATIC FACTORY: THE AGE OF HARMONY, LEISURE AND PLENTY?

by Professor B. R. WILLIAMS, B.A.(Melb.), M.A.(Ade.)

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I

WE are not on the threshold of an age of fully automatic production. We are moving that way, but slowly. It is nonetheless important to think about the automatic factory now; for our thinking now will largely determine what it will be like and how long it will take to achieve.

The title of my Paper is a question. Would the growth of the automatic factory—the actual manufacture of acceptable products without direct human intervention—take us towards an age of harmony, leisure and plenty? To this question three answers have been given "No", "Yes", and "It depends . . . ". I will first consider these problems of the future. Then, I will consider the probable rate of change, since our chance to make a satisfactory adjustment to change will depend on the time we have for it. Finally I will say something about the implications of present developments.

A good many people, both informed and uninformed, have attempted to appraise the possible effects of the automatic factory and various argu-

ments have been marshalled both for and against. At this Conference we would be wise to examine these prognostications in some detail.

Argument Against

1. The argument that the automatic factory will not benefit society may be broken down into several theses:

(*i*) that the automatic factory will create technological unemployment. This thesis in a more sophisticated form is that "if capital investment were to increase while the need for manpower dropped, the consequent rise of capital's share of the national income would cause widespread unemployment and have an adverse effect on the standard of living".

(*ii*) that the unemployment will create tension and discontent within society. The bitterness and frustration of "men without work" will infect those with work, and machines will be regarded as competitors and supplanters of men.

(*iii*) that the cost of change will rise greatly. A versatile machine will be more expensive than a special purpose machine and this will lead to a still greater emphasis on keeping long unchanging runs till the equipment is worn out.

(*iv*) that unless all change is rigidly programmed—a programme that would entail knowledge of, or control over, acts of God, the Queen's enemies, and you and me—the system may become unstable. For in a multiple loop system unexpected events in one loop can make the whole system unstable.

(*v*) that the automatic factory will destroy its own foundations. Mass production needs long runs and it needs a mass market. This mass market was created by massing workers together in factories. The automatic factory will un-mass workers. The mass market would then have to be re-created by taking away free choice, and by positively conditioning the citizenry to fit the needs of the factories.

(*vi*) that the small number of engineers with the ultimate control of these automatic factories could, by threat of pushing the stop-production button, hold society up to ransom: the ransom being control of man's consumption and habits in the interests of the machines. The automatic factory, then, will provide an open sesame to Huxley's "Brave New World".

(*vii*) that the vast speeding up of production will produce a growing scarcity of raw materials. This scarcity will not be spread evenly between nations. This will intensify friction between nations. Add to this the discontent at home due to unemployment and it is easy to see that the push button factory will increase the risk of a push button war.

In any case (*viii*) that the automatic control systems are similar to the nervous systems of humans and animals. In creating automatic factories we create robot machines. How can we be safe from these Frankenstein monsters?

I will not at this stage comment on these theses, except to say that acceptance of one does not entail acceptance of all. You will all have noted the influence of science fiction within my list!

Argument in Favour

2. The argument that the automatic factory will benefit society may also be composed of several theses:

(*i*) that the object of production is to create things for men to use or consume. Each piece of mechanisation releases hands, brains, and energies for new forms of production. The continuous mechanisation that constitutes an automatic factory will bring a vast increase in production per man. This is the way to create plenty.

(*ii*) that mechanisation releases hands, brains, and energies, which may be used to create new commodities. When after creation the new forms of production are made automatic, new room is created for still newer commodities. If men choose not to create new commodities, the labour released will not be "unemployed"; it will be "employed" in leisure.

(*iii*) that with greater wealth there will be an opportunity for a longer and broader education. The type of skill required will, in any case, not be a narrow specialist skill; and insofar as man uses part of his potential leisure for the creation of new forms of production, there will be a vastly expanded need for research and development.

(*iv*) that the automatic factory will still need the labour of skilled maintenance men and programmers. Unless production goals were never-changing and process conditions always predictable, unaided computing machines could not solve all programme problems. Thus there would be two highly skilled types of labour controlling the machines. Man would no longer be an appendage of the machine to be paced by the machines; labour would acquire a new dignity and interest.

(*v*) that without the need for mass labour supplies there will no longer be need for vast straggling conurbations. Industry will become decentralised, even rural.

(*vi*) that much of the present industrial unrest exists because man is paced by the machine and performs routine tasks. The automatic factory will dispose of this problem. It will also avoid the need to mass workers together in a factory and control them through a complicated system of status and hierarchy. The problem of human relations in industry will become relatively simple. From these last three theses we should expect industrial harmony, unless the system is unstable.

(*vii*) that the fact that a multiple loop system may be unstable, should not be taken as proof that the economic system would be unstable. There is a difference between the automatic factory and an economic system composed of automatically linked automatic factories. In fact, programmers will be needed in factories to exercise judgment in control of unexpected events; and State planners, aided by computing machines, could send instructions to these programmers that would correct approaching instability or quickly offset it. Planning against instability at any rate in a closed economy would be quite simple. Thus the movement of the different sectors of the economic system could also be kept in harmony.

(*viii*) that with automatic control the amount of capital required to produce each unit of output tends to decline with full utilisation of capital equipment or capital saving invention. This will make it easy to export capital for the development of food and raw material resources in undeveloped countries. We will thereby secure our food and raw material base at the same time as we help to raise standards of living in poorer countries. This will help towards world peace.

Possible Outcomes

3. And now for the "it depends" type of answer, which I will use to comment on the preceding theses. Most of these represent *possible* outcomes—the best and the worst possibilities: they picture the dual nature of man with his continuing capacity for wisdom and folly, creation and destruction, good and evil.

I will consider these conflicting theses in terms of the three main questions posed in the title: Leisure? Plenty? Harmony?

(*i*) If automatic control and operation in factories is economic, as already in some fields it is, it must increase output per man. This must increase the possibility of leisure, unless in other fields such as agriculture and services there is an offsetting increase in demand for labour. This possibility I would not in this context take seriously. It implies either that there is technical decline in non-factory production, or that the whole increase in real income was counterbalanced by expanded demand for material goods and services.

Hours of work in this country have come down from about 60 in 1860 to 46 at present, and the age of entry to the labour market has increased. In the U.S.A. from the 1890's to 1930, an increase of 1% in hourly real wages brought a .25%—.33% fall in the labour offer. In other words, one-third to one-quarter of the gain was devoted to leisure. In Australia, still more of the gain was devoted to leisure—i.e., to national occupations such as tennis and surfing!

The Problem of Leisure

What percentage of the potential leisure will be used depends on the rate at which new material wants are created. From past experience it seems quite safe to say that some part of the potential leisure will be taken. A working week of 30 hours is quite conceivable.

But we should not pitch our expectations too high. There is more work than factory work, which in Britain uses only one-third of the labour force and is falling relative to other employment. In households, schools, laboratories, and distribution, the potentialities of automatic production are very much less. In the course of time we may devote as much labour per year to training a child as we at present lavish on champion race-horses. Certainly I would expect the labour used in education to rise with growth in real income and with an increased demand for scientists and technologists in research and development and highly skilled maintenance men in production. This is likely to entail a breadth of training and therefore a length of training to which at present we do not aspire.

This expansion of education could help solve that oddly worrying problem—the problem of leisure. If society made up its mind about the object of education and also produced an education system appropriate both to the new technology and a 30-hour week, the problem of leisure should vanish. Unfortunately there is clearly no easy and obvious solution—certainly it is beyond the scope of a "mechanical brain"—and since the family is a basic educational unit we cannot "simply" arrange it through schools. I would, however, expect the problem to become much easier of solution than now appears, because through automatic control and production we would get rid of the *mass* of workers in a factory and so destroy the mechanistic concepts of the functions of workers in mass production.

But what of the potential threat to leisure from robots with brains? Frankensteins and robots are very useful devices for modern parables and satires on man. But these new "mechanical brains" can no more think than a radio can talk. If however some villain or lunatic of the human species *decides* to explode a hydrogen bomb—that is serious.

(*ii*) Saying that society will choose to take part of the potential leisure created by automatic production, implies an increase of plenty. As this way of looking at the problem biasses the case against those who argue that scarcity will be created through exhausting natural resources, I will examine that directly.

It is quite clear that some of our resources are exhaustible: indeed, all minerals. Insofar as we speed up production, we bring the time of exhaustion nearer, but how near is quite another question. Our coal reserves are vastly diminished and more difficult to mine, but uranium will before long replace coal as a source of power. By the time uranium is exhausted, doubtless other minerals will have become usable. Just as we find new uses for old minerals, so we find old uses for new minerals. How long this can go on no one can say, other that at present rates of exploitation it is a very long way off.

But what of food? This is not a problem of automatic factories, unless automatic farming devices that mine the soil are introduced.

Effect on Material Wants

Plenty, however, is a relative term and beyond the level of subsistence a psychological problem. We live in a state of plenty if our material wants expand less than our incomes. How will the growth of the automatic factory affect the rate of growth of our material wants? Well, it depends . . .

If society is roughly equalitarian so that we are not striving madly to keep up with the Jones's; if the automatic factory is based on flexible machines and is decentralised so that we avoid danger (1. *v*); if the programmers and skilled maintenance engineers with jobs that give scope for ingenuity and pride develop the personal traits of the old craftsmen; if machines are not treated as instruments in a vast competitive struggle; if, *via* a richer system of education, men

other than saints realise the vanity of a strained pursuit of material goods—there will be plenty and a feeling of plenty.

But things could be different. There could be a vast competitive race to speed up production more and more in automatic factories; to create bigger and better purely *technical* solutions of production problems; to condition men to want more and more of the goods that were being poured off the production lines; to conquer and exploit the stars and the planets. Such an approach would not create a feeling of plenty, but a feeling of dissatisfaction.

Whether the one or the other is the outcome would depend on the institutions created to regulate economic affairs, and on society's goals or set of values.

(*iii*) I come now to the third question in my title. Will there be harmony ? Will machines compete with men ? Will there be an impassable barrier between a few controllers and the rest ? Will the system be unstable ? Will international relations get worse ?

Who will be the Controllers ?

Machines can create unemployment. It is possible to envisage a situation where automatic production replaces men in a few industries, but not in others; where in the technically unprogressive industries there was no incentive to expand employment or reduce hours. In this case the potential leisure would not be willingly taken in part by all, but forced on a few in the form of unemployment. This problem of uneven growth could be solved by a statutory reduction in working hours, unless the technically unprogressive industries were faced with fierce international competition. In this case machines would compete with man, unless there was an international agreement on hours, or subsidies to the unprogressive industries, or unless the technically unprogressive industries were made progressive. This, however, is not a problem of the automatic factory as such, but of uneven rates of growth towards it. The growth problem is capable of solution—it is one of the many aspects of the "social control of business" of which we are becoming increasingly conscious.

Will there be an impassable barrier between the controllers and the rest ? There are two issues here : will the controllers be able to push the rest around, and will there be a few supremely intelligent men who understand the machines, with the rest non-entitical ?

Well, who will the controllers be ? Owners ? Programmers ? Maintenance men ? People responsible for research and development ? or distribution ? or education ? or agriculture ? There may not be any owners, but there will certainly be many "controllers", many of them outside automatic factories, and there is no reason to expect any identity of interest in, or view about, controlling "the rest". Furthermore, these many controllers will be interdependent. The factory controllers could not take over farming. The factory programmers might even be unable to do the maintenance ! That is not to say that a society with automatic factories could not be totalitarian. It could be. But it need not be. There is nothing new about this problem. As in our present societies "it depends . . ." Given peace, given the absence of deep depressions, this country should find it fairly easy to keep a democratic society.

Importance of International Action

But will depressions be avoided ? Will the system be stable ? In a closed economy it should be fairly easy to avoid instability (see 2. *vii*.) The main danger to stability would come from outside the economy : from serious depression abroad, or from technical progress abroad that made one or two of our main industries obsolete and uncompetitive. This is a familiar problem. As now, success will depend on agreed international action. This is the key to the solution : it is the key to the more than this, for on it also depends the chance to build automatic factories.

Will the automatic factory intensify the problem of international relations ? It need not. This will largely depend on whether or not the automatic factory creates a feeling of plenty, and on whether we use part of growing real income to ***help*** undeveloped countries develop *their* resources (2. *viii*).

So, I would conclude, it all depends, and it depends on what institutions we create, what values we develop in the near future, on what time we have to see the problems emerging.

II

I think we have a great deal of time to see the problems emerging. We have good reason to expect growth towards the automatic factory to take place at different rates, and in different ways, in the various industries.

1. The great advance towards the automatic factory in oil refining is due to a combination of technical, economic and historical factors that is not found in older industries. For this reason the advance to an automatic factory is likely to be both more difficult and longer sustained in most other industries.

The technical reason in the case of oil refining is that, consequent on the introduction of cracking towers, refined oils are produced by a physio-chemical process that is *continuous*. Here the growth of process control was in itself the major step towards the automatic factory. (Outside the oil industry there have been, of course, extensive applications of automatic control to processing variables, such as pressure temperature flow and level, but it is only in the chemical industry that this process control itself takes us near the automatic factory stage. Automatic process control of furnaces in a pottery factory does not take it near the automatic factory stage, nor even automatic control of open-hearth furnaces for steel production.)

The economic reason is a two-fold one. In oil refining, as in certain other heavy chemicals, a vast output of a reasonably standard product is produced. There was, in addition, a tremendous *increase* in demand—a demand that could not be met with the old batch process methods. It would be quite impossible to produce the present output of refined oil with

manual operation. The rapidly expanding demand gave both the incentive and monetary opportunity to introduce automatic control.

The historical reason is that there was no past to weigh down the present. Management and marketing methods were evolved along with the techniques of large scale refining. In older industries, the growth of the automatic factory will involve quite fundamental changes in management methods that grew up with and were appropriate to non-automatic methods. Furthermore, I should add, the management problem is on the whole simpler in the processing than in the manufacturing industries.

Following this it may be useful to divide the impediments to the introduction of the automatic factory into technical, economic, and human.

2. I have implied that there is no technical impediment in the case of an oil refinery. Even here, however, there is still a considerable technical problem. To get the maximum yield, temperatures and pressures must be adjusted whenever the quality of the crude oil varies. This has led to thinking about end-point control, which would require both *continuous* analysis of the product and a computer capable of using analysis reports to adjust the various controls. Both the continuous analyser and the computer present significant technical problems, though these problems are simple compared with the potential problems in other industries.

In some industries the essential properties of the raw materials is not known. Where this is so, it is not possible to write out a foolproof list such as: If you find properties *a* and *b* in the material do *z;* if *c* and *d* : *y;* if *b* and *c* : *x*. It is not possible in such cases to leave the action decisions to the computer, since the computer can only solve problems that have been anticipated in its building.

Where the process of production is not continuous, it would be necessary to join up separate automatic machines into a *system* of automatic controls. Such a system might be non-linear, and as such it may be beyond the present range of computer control. Mathematicians—I hear—have not yet worked out the full theory of non-linear systems.

The Problem of Cost

3. (*i*) The economic problem is one of cost: what is the cost of automatic control compared to the cost of human control? In general, at the moment, it is high. The reason is fairly simple. A machine or a group of machines is more expensive when automatically controlled. This expense is only worthwhile when output is greatly increased, but this depends on the size and stability of the market. Where the market is limited or where it is often necessary to re-tool or reset, the expensive controls would be left idle too long for them to be economic. In general, cost rises with complexity. This also affects computer costs—the greater the complexity, the greater the possible number of situations, the greater the number of solutions or instructions to be built into it.

It may be argued that some automatic machines are capital saving. This is true, but true in a limited field. An automatic transfer machine for machining cylinder blocks, where the machining, boring and reaming are performed within the same machine, may be cheaper than the several machines it eliminates. In this case, clearly, automatic production is economical: the cost of the machine is less, the labour cost is reduced, the output is increased and the product is more uniform. Note, however, that this transfer machine prepares cylinder blocks—it does not make a motor car. We cannot transfer the reasoning to the whole factory. Further, even such a spectacular piece of automation is not of general application: the large single-purpose machine is relatively easy to make automatic, but it is not easy to pay for except where it can be used for a long run.

The long run of standard product, the continuous process—these are the conditions that most favour the growth of the automatic factory. But they are not typical of industry. We do, however, find pieces of work that favour automatic control even in industries dominated by short runs, and lest I should seem to be too negative, I will now say something about them.

(*ii*) "Pieces of automation" that are economic are many. One very important example is that of the automatic quality control that has grown out of "instrumentation". If a product must be produced to fine tolerances, as is the case, for example, with turbine and compressor blades for modern jet engines, and if the production cycle is short, the cost of letting a machine run out of control is great. Here the cost of automatic control can soon be paid for in work not spoilt and in the equipment no longer needed to produce only a sample of good work. Fast and continuous inspection and control, whether of turbine blades or a set of dials and knobs for boilers, is beyond human beings. In such cases the high quality is only made possible by the instrumentation and automatic control. In other cases, such as atomic energy where the work is too dangerous for humans, automatic controls are equally indispensable.

These automatic quality controls, it will be noticed, are not labour-replacing. They add to what labour can do: they extend the range of production and make possible the employment of new labour released, say, by transfer machines.

In other cases, pieces of automation become economic because of the scarcity of labour. Thus automatic handling and machine loading devices have become increasingly economic with the post-war shortage of labour. That there is a shortage of labour for handling and loading is itself a sign that labour has more urgent uses, many of which were provided through new activities made possible by automatic quality control. We may expect some further autonomous inventions that will be labour saving, but as these may be balanced by the desire to take more leisure with an increase in real income, I do not expect any significant new labour displacements by these "pieces of automation".

Human Impediments

4. Just as there are human efforts directed towards the creation of the automatic factory, so there are human impediments. I mention three:

(*i*) *Fear.* Fear is one of the many causes of stupidity. There are certain fears about the development of automatic controls, which if not allayed, will delay applications which are both technically and economically possible.

Management may fear that automatic controls will bring an excessive level of overhead cost or a host of technical problems that will be unmanageable. Whether automatic controls will produce " excessive " overheads will depend on the type of control. Some of this fear results from thinking too much in terms of devices such as the transfer machine, which has only special application. Of more general application are automatic copying lathes, handling and machine loading devices, and quality controls. Such controls, by bringing fuller utilisation of equipment, or by reducing waste, cut down the " burden " of overheads.

The fear that there will be a host of rather " unmanageable " technical problems may have some basis. The problem of maintenance will increase, and the type of management needed will change—but the problems are only unmanageable in terms of *present* management and labour skills. Even now, applications of automatic control are hindered by the shortage of technicians. This was to be expected. With a sudden growth in demand for new technical skills, demand must for a time outrun supply. Certain shortages, however, may continue—engineers with sufficient mathematical knowledge to do creative work in control systems and design engineers with the ability to redesign products in terms of the potentialities of automatic control. Change in the type of manager and management will also change with the production problem, but I do not expect this to happen at all quickly.

Labour fears of unemployment may lead to demands that jobs be guaranteed, that redundant workers be attached to new machines, or that new methods be not introduced. In some firms this fear may have no basis; in others this fear can be calmed by guaranteeing employment—by providing for redundancy through retirement and retarded recruitment, but not in every case. Technical progress, whether it involves automation or not, always brings with it redundancy in one place, shortage in others. If the community is to profit from the technical progress, some must change jobs. Because the fear of unemployment has fallen, " labour " resistance to change has diminished during the post-war boom. If we do not maintain full employment, and if we lose that new attitude of management to labour which has been induced by scarcity of labour, serious labour resistance, based on fear, will re-emerge.

(*ii*) *Ignorance.* Many firms do not know that their methods of production are extremely primitive; or, if they do know, think that they can buy a scientist (on the cheap) who will transmogrify the firm by his very presence. I wonder how many of the ignorant take the trouble to come to Conferences such as this ?

(*iii*) *Indolence.* Some firms know that they are backward, but do nothing about it. In many sectors of industry there is not even enough competition to eliminate the ignorant and indolent.

Indolence (or ignorance) may even exist in our various academies. If so, they will be slow to adjust their conditioning and teaching of children to meet the new technical conditions. Even today many children are trained for the lives they would have lived in the horse and buggy days. Certainly there are some very difficult problems to solve. How many design engineers capable of coping with the advanced mathematics involved in creating automatic control systems are we training ? How many scientists, even among those going into management, have received any training in economic and human relations ?

I will go no further with my list of impediments. My purpose in listing them is to explain why I do not think the automatic factory is imminent and to help in the preparation of an agenda of obstacles to be overcome; which, I take it, is one of the main objects of this Conference. Because there is no good reason to fear " The age of the automatic factory ", it is worth striving to remove these impediments.

III

I will now summarise some of the main effects of such growth of automatic production and control as we may expect in the near future. This should be seen in the context of Britain as a trading nation.

1. In the interwar period, the U.S.A., Germany and Japan gained ground in international trade at the expense of Britain. Britain's export industry was for long directed towards meeting the demand of non-industrial countries. This position was undermined by the growth of Japanese competition and a growth of industry in the non-industrial countries. This called for a shift to new types of export based on the newer industries that were expanding in world trade. Britain's shift to this type of production was too slow.

The foreign trade from which Britain stands to gain most is trade in goods in which capital per worker and embodied technical knowledge is high. This is the field in which pieces of automation are the condition of production or an indispensable aid in efficient production. Britain's future in trade, therefore, depends on rapid progress in overcoming the fear, ignorance or indolence that retards the use of automatic controls, and progress in inventing and producing better and cheaper control mechanisms.

The profit from this development is three-fold. There is the export of the product made with the aid of automatic controls, e.g., oil and nuclear products. There is the direct export of the control devices or machines embodying them. There is the saving of imports resulting from the development of the new industries. For example, the growth of the petrochemical industry in this country has made it increasingly possible to provide here the synthetic organic chemicals used in plastics, nylon, detergents and drugs.

2. The demand for imports tends to increase with greater production and consumption at home. To make possible this higher level of imports, we must increase our exports and that largely depends on a rapid industrial application of science and technology. But full employment also depends on this—slowness in applying science and technology, whether due to

an inability or a refusal to apply it, will bring depression in export trades.

Greater production per head itself depends on the industrial application of science and technology and of this automatic control mechanisms are an important part.

3. With the growth of control mechanisms machines have been run at higher speeds and used more fully, wastages have been reduced, the quality of product has been increased. There has been in consequence a fall in the ratio of capital required to produce a unit of output. This " Declining Importance of Capital ", as Mr. Colin Clarke calls it, does not necessarily mean that we will use less capital in the future than in the present—that depends on how much we want to increase output. It does mean, however, that the capital cost of making output grow is less than it used to be. Offsetting that, the requisite human skill is more than it used to be.

It should, therefore, be increasingly possible for the advanced industrial countries to lend capital to the undeveloped territories. Possibility and interest go hand in hand in this case. Such an export of capital would help both the development of markets for industrial goods and the supply of food and raw materials. This is not, however, a mechanical problem. The lending of capital or the investment of capital in undeveloped territories must be based on agreements to share the benefit, and be accompanied by recognition of an interest in both the social advance of men and the development of markets; otherwise the capital export will create unrest and instability.

At home the implication of the changed capital-output ratio is that we should bring a certain shift in our attention from things to persons. That is to say, we should use up rather more of our material resources and human ingenuity on training and selecting managers, on training and ensuring the best use of scientists, technologists and technicians, on solving the problem of function, reward, and authority in factories.

These are all difficult problems, but our technical as well as our human advance depend increasingly on solving them.

DISCUSSION GROUP 2A

"AUTOMATIC TRANSFER MACHINES "

(concluded from page 534)

Staff

If we examine the ratio between the staff of superintendents and the workers over the last ten years or so, we can see a slight falling off in our workshops; but for a valid appreciation of this progress we must compare the supervisory staff not with the workers but with the quantity of work produced. From this point of view, the falling off is considerable since it reaches approximately 40 per cent.

Maintenance

The standardisation of the special machine elements has allowed considerably increased production in our workshops without a proportional increase in the maintenance staff.

To gain a rough idea, we will take the example of a department of 3,400 people where the daily output of all the mechanical parts for 600 4-h.p. cars requires a maintenance team of 133 people, of whom 30 are particularly assigned to 200 special machines. This proportion seems reasonable if it is considered that we should need 1,000 standard machines to replace the special machines and that the maintenance staff involved for these machines would be approximately 170 people, an increase of 130 per cent. upon the present rate.

To return for the last time to the problem of electrical controls, it must be stated that the department periodically services switches and relays.

Although a preliminary examination of the electrical equipment for similar machines appears complicated, it must be said that this first impression is not borne out by actual fact; experienced electricians are able to cope very quickly with breakdowns, can detect failures, and repair them in a very short time.

At present, maintenance of the mechanical and electrical equipment is divided between plant and electrical departments. Due to excellent liaison this division is not annoying to either party, but the creation of a team of maintenance men may be successfully accomplished with electricians and mechanics working together.

The New Idea

The description of the work involved prior to the entry into service of automatic machines amply demonstrates the variety of knowledge required for this plan. The requirements of the mechanical staff, electricians, production, despatch and transport departments, the department responsible for erecting building and installing fluid distribution and conveyor systems must all be interwoven. There can be no question of treating these problems separately and successively; the result of each part of any plan depends upon the solution of other problems; each must be examined together and no one solution is the best unless it combines happily with the others. One cannot hope for any one person to possess the knowledge necessary to solve such a mighty problem alone.

In this increasingly industrial world, the successful result cannot be the achievement of an individual. Great as his value may be success will come to those who have developed their knowledge together, in the team spirit.

AUTOMATIC TRANSFER MACHINES

by P. BEZIER

M. Bezier graduated in 1930 from L'Ecole Nationale d'Ingénieurs des Arts et Métiers, and in 1931 from L'Ecole Supérieure d'Electricité.

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THE technical vocabulary usually denotes under the heading, "Transfer Machines", those multi-station machines in which the components remain fixed throughout the sequence of machining operations and are moved from station to station between each stage of machining.

According to the method of movement these machines are defined under the main headings of Rotary Table (Fig. 1), where the components are moved in a horizontal direction on a horizontal plane; Drum Transfer (Fig. 2) where circular movement takes place on the vertical plane; and machines (Fig. 3) where movement is linear, to which certain makers give the term "transfer" but which are otherwise known as "processing" machines.

Such machines have generally been introduced within the last twelve years or so.

Since they are often large and expensive their use is only justified when a certain number of requirements can be fulfilled at the same time. The first of these is for large scale production, and this is the reason why they are found to be in use mainly in motor car factories.

Up to the present time these machines have been almost exclusively used for processing operations, although American magazines have recently included descriptions of similar machines used for assembly operations.

The design, operation and use of these machines involve problems which are the concern of all departments of a complete Company.

Technical Description

At present, machining operations effected on these machines are drilling, reaming, tapping, milling, shaping, honing, chamfering, spot facing and broaching. Apart from particular examples which are not within our present scope, these machines are mainly constructed with interchangeable elements. They consist of machining units fitted as required with multi-heads, with bush plates for such tools as drills, reamers, tool-holders and automatic transfer mechanisms, thus ensuring the movement of components from one work station to another. For a better appreciation of the problems involved in the use of these machines, it is necessary to give a brief description of the elements themselves.

Machining Units

These are basic elements of the machine and are capable within themselves of a complete machining cycle including the rapid advance, feed, rotational movements of the tools and rapid withdrawal.

The earlier units (Fig. 4) were constructed on similar principles to those of a drilling machine, that is to say, the spindle holder was carried in a sliding sleeve. This arrangement was found to have serious disadvantages when a long stroke was required, or when the weight of a multi-head was considerable. It was these circumstances which brought about the development of the present unit head which briefly consists of a body, spindle drive, motor, traverse motor, the whole mounted on slides of either square or dovetailed shape (Fig. 7). These earlier heads were fitted with a cam feed as against the present practice which is to use either hydraulic or mechanical means of advancing and withdrawing the unit heads. Illustrations of hydraulically operated unit heads are shown in Figures 5 and 6.

The two systems will be considered, and we will attempt to define the good and bad points of each.

To the advantage of the hydraulic units it may be said that the variation of the feed is easily effected; that relatively fast feeds may be obtained (approximately 100 m/m per sec.) and possibly a somewhat lower replacement cost, but it must be appreciated that it is difficult to avoid losses of expensive lubricants which thus dirty the workshops.

It is almost inevitable that temperature changes result in variations in the viscosity of the oils in use, resulting in turn in greater losses or variations in flow through the control valves. When the fluid temperature changes either as a result of workshop heat or of working temperature, adjustment of the machine is necessary to maintain working efficiency. This difficulty clearly prevents the use of hydraulic feed

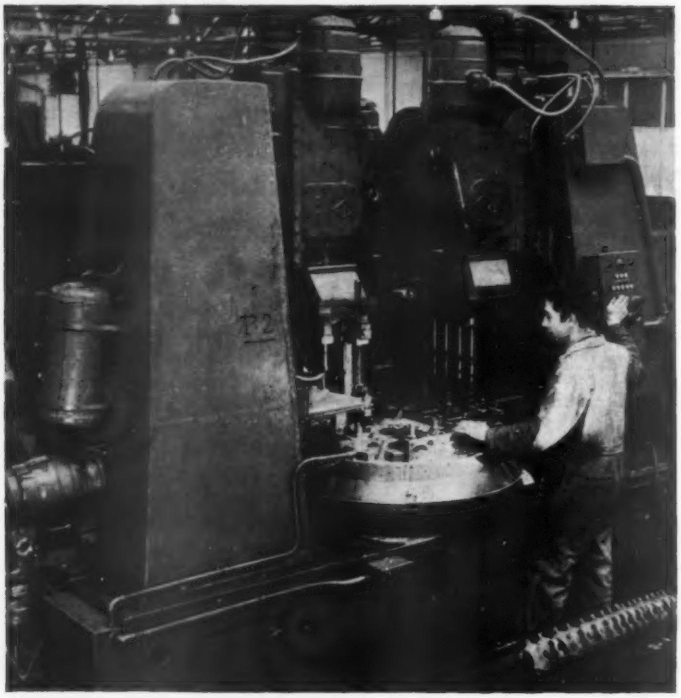


Fig. 1. Renault indexing machine for processing Renault 4 h.p. cardan shaft bushes.

Fig. 2. Renault drum transfer machine for processing cock and unions.

for tapping units. The accumulation of air in the pipes or in the cylinders constitutes an elastic mass, the presence of which is detrimental to the precise functioning of the system as a whole. The pressure circuits must therefore be constantly checked by careful bleeding.

The worm drive, on the other hand, has the advantage of absolute constancy.

These units are now well known (Fig. 7) and reference may be made to the numerous descriptive articles published on this subject, in particular that of Mr. Holbeche of Austin Motors, which was recently published in the " Machinist ".*

Suffice it to say that the traverse motors have an electric brake, which allows the fast feed mechanism to work accurately, since there is no need to include a non-reversing gear. These brakes ensure precision to the order of .5 m/m (.02") at the end of fast traverse.

It is easy to modify the cycle of these units by adding of extra relays, or by altering the wiring system, since the same unit is capable of any working cycle. In Figs. 8 and 9 may be seen electrical circuits applicable to the usual working cycles.

Despite the apparent complexity of the circuits, which has often made technicians doubtful about the difficulties of repair, the Author can confirm that after 10 years of practical experience of these units, with 3,000 heads in service, repairs are easier and faster than on hydraulic machines, and that it takes only a few weeks to instruct the electricians who specialise in this type of work

Handling Units. The most up-to-date handling units will now be described.

Rotary Tables — are driven by mechanical (Fig. 10), pneumatic (Fig. 11), or hydraulic (Fig. 12), systems.

The mechanical systems require combinations of the Geneva Cross type (Fig. 13) or friction clutch change gears (Fig. 14); the latter have the advantage of working with a more constant acceleration during the cycle.

Problems to be resolved during the design of these mechanisms include speed of indexing, precision of the indexing division, rigidity during working, and interchangeability in case of replacement. According to requirements an indexing division between ½ and ⅛ of a turn for tables supporting a load between 200 and 3,000 kg. must be ensured. Thus it is obviously difficult to find a mechanism covering such varied conditions whilst allowing of the utmost standardisation. Precision of indexing requires a low operating speed for the locating plunger and care must be taken to ensure that the stopping shock to the table does not affect location precision. The Geneva Cross mechanism, elsewhere inconvenient, fulfils the above conditions very satisfactorily. Working rigidity is ensured by locking the table base when indexing and location are complete (Fig. 14). This precaution is necessary when several operations are involved, such as drilling, recessing and milling.

*now " Metalworking Production "

Drum Transfer Machines

These have been very widespread, since they are normally smaller than indexing machines and they allow working to take place in two opposed directions.

There are, however, disadvantages with the drum type of machine; for example, tool changing is difficult unless long stroke units are used; also, as the drum is on a vertical plane, it is difficult to place more than three working stations around the perphery of the drum.

Furthermore, clamping after indexing is more essential than for rotary tables and the present practice is to use spindles of the multi-head type to effect location of the drum so forming an interlock between the bed, the drum and the unit during the working cycle.

Transfer Elements

The main bed of the transfer machine constitutes the line along which the components pass from one machining operation to another. Numerous descriptions have been published in the technical press since the inauguration of this type of machine; but the details of these will not be entered into here, only several particular points being dealt with.

When the workpiece is a large flat machined face with two locating or dowelling holes it may transfer directly (Fig. 15) on the machine slides (non-platen type). When centering points, or turned or ground faces and narrow limits are involved, they may be located by datum points or ½ bushes (Fig. 16). On the other hand, if the work piece is of an irregular shape it has to be mounted in a fixture with a flat base and tempered location bushes (Fig. 17). The fixtures must then be returned from the exit station to the entry station. There are several methods of doing this, each one having its own advantages. Pulley blocks with auto-motors working along a straight rail on a closed circuit have been used. This method is quite economical and does not take up extra room since the pulley blocks move above the machine. Nevertheless, if the fixture is not dry as it leaves the washing station, care must be taken not to allow it to pass above such parts of the machine as electric motors or relays, which may be affected by drops of liquid falling from the fixture. When the length of a machine is about 10 metres or if the cycle time falls to approximately 1 minute, the speed for moving the pulley block must be greater than .3 m/ per second. Special precautions must then be taken to prevent the load swaying at the end of its journey. The main inconvenience of this method is found in the difficulty of stocking the fixtures away from the machine when, for instance, complete cleaning is required.

We prefer to use the gravity return conveyor belt where the return of the fixtures is ensured by a pawl bar (Fig. 18), which method obviously increases the floor space for the machine, and to avoid this inconvenience Austin's have designed return systems whereby the fixture moves through the bed extension

Fig. 3 *(left)*. **Renault transfer machine for " Fregate " cylinder blocks.**

Fig. 6 *(below)*. **Archdale slide-mounted hydraulic drilling head.**

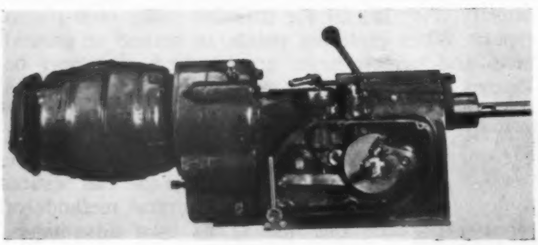


Fig. 4. Sleeve type drilling head with cam feed.

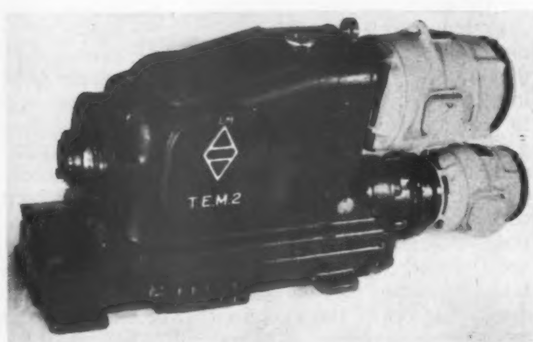


Fig. 7 *(above)*. **Renault slide-mounted worm driven drilling and tapping head.**

Fig. 5 *(left)*. **Kearney & Trecker sleeve type hydraulic drilling head.**

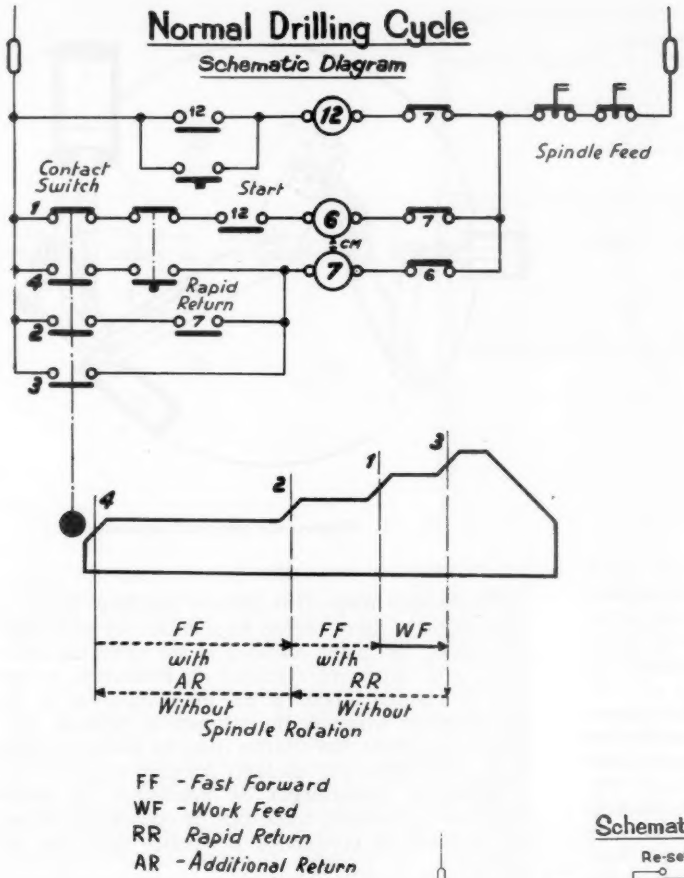


Fig. 8. Wiring diagram for Renault drilling head.

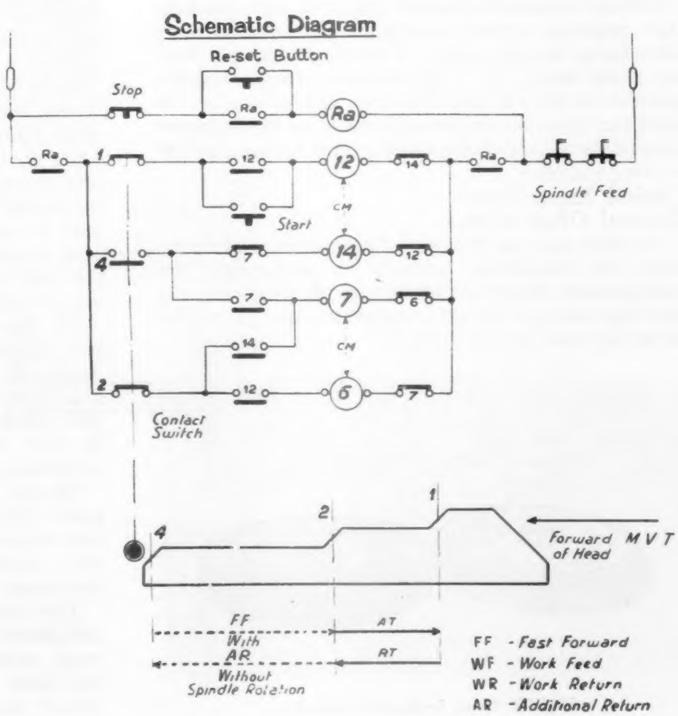


Fig. 9. Wiring diagram for Renault tapping head.

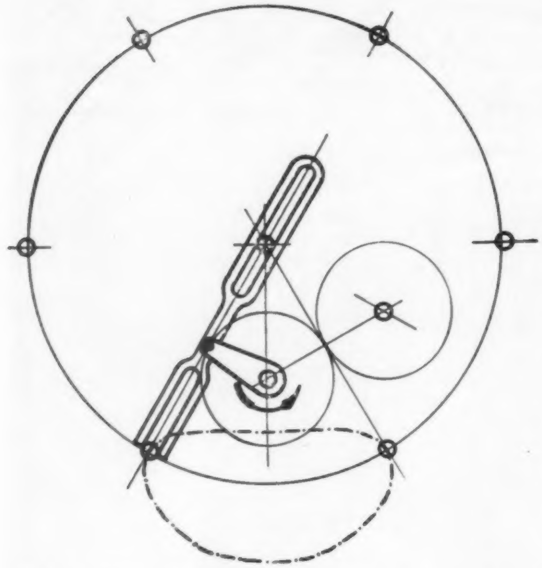


Fig. 10. Evolution diagram for Bullard Mult-Au-Matic lathe.

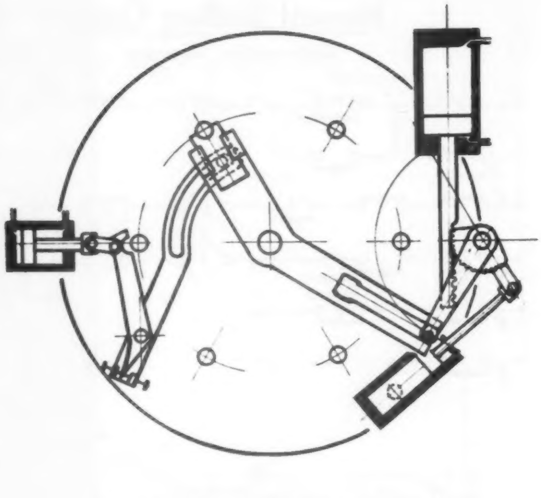


Fig. 11. Osborn air operated turntable.

of the transfer machine. (See the "Machinist" of 4th February, 1955, pages 191 and 192.)

This method reduces floor space, but if the fixtures are extra high, the passage required weakens the bed extensions, which are in turn unable to support units working under great strain.

Certain American makers (Fig. 19) have planned their machines on the rectangular basis, the two long sides being the machines and the short sides the linking chain conveyors. This requires two automatic transfer units for moving the fixtures along the machine; thus the increased cost must be balanced against the saving of floor space, and is only justified on long machines.

Capital Expenditure

General Observations

In order that the Planning Department may determine the maximum amount of equipment, the management should decide the production rate, the time lag until production commences, and the capital to be expended for production.

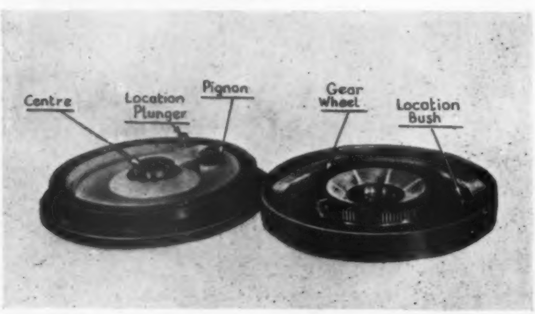


Fig. 12. Cross hydraulic turntable.

Production Rate. It is obvious that large quantity production requires perfect equipment, for only such production can make economical use of highly automatic and expensive machinery. Reduction in the cost of manual labour is the main economy to be expected, for whatever the production methods of a given component, the relative costs for power, cutting tools, lubricants, and coolants scarcely varies.

Moreover, replacement of machinery by more expensive substitutes could not be considered unless the increase in production is greater than that of price.

It is relatively easy to estimate the direct manpower economies to be expected from the use of such equipment and to check the time lag if outlay costs are to be covered. Other considerations arise which are much more difficult to foresee with any exactitude. The perfection of equipment should lead to manpower economies, but it may not only lead to extra original outlay, but to an increase in the risk of untimely stoppages or breakdowns, in which case a maintenance staff is required.

On the other hand, if the equipment is strong and well adapted to the work to be covered these inconveniences are negligible. The more widespread these machines become, the greater the technical perfection, the increase in strength, and reduction in prices. In this field the results of standardisation are extremely important.

On the other hand all economy from direct manpower increases the supplementary economies for installation and maintenance, outlay for cloakroom and canteen facilities, and pay and accounts structures.

The use of additional equipment such as hoists, automatic conveyors, and automatic clamping equipment, improves working conditions, reduces fatigue and does not prejudice health. The advantages gained therefrom, if not immediately obvious, are

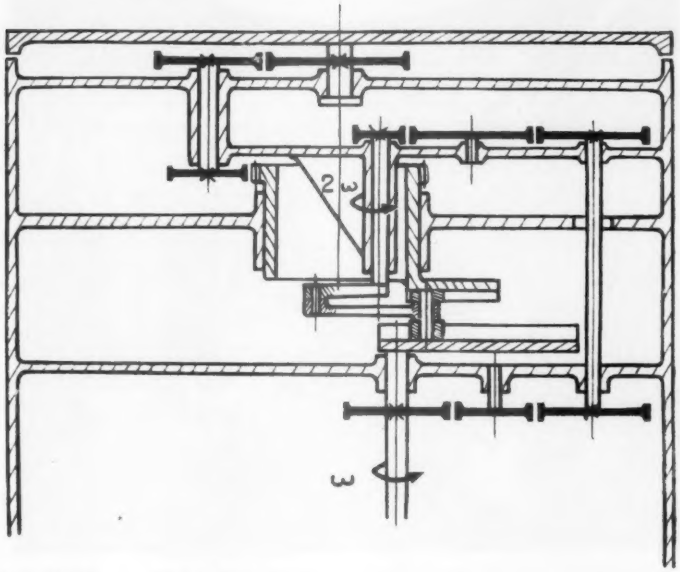


Fig. 13. Renault turntable with variable radius Geneva cross arm.

reflected in the factory's welfare and medical services.

Modern equipment must completely fulfil all safety requirements. From this point of view it is favourable to insurance companies and their premiums, and to the costs of absenteeism. Everyone knows the weight upon the national budget of expenditure due to absenteeism and ill-health throughout the working world. Other economies result from the decrease in workshop area for the production of a given article. The system of performing machining operations on an automatic transfer line also results in a considerable reduction in the number of workpieces in various stages of completion. Standardisation of production methods, whilst reducing the risk of break-downs, further allows for reduction in stocks which often represent considerable capital tie-up, the interest being charged to overheads.

Time Lag

This condition, resulting from the policy of the management, is one of those which is determined most directly by the desired result. In effect, if the production rate required justifies expensive machinery, the time lag must be fixed to allow for attainment of an acceptable solution. The maker will appreciate the importance of always being on his toes to cope with any new requirements, or to issue new models when good selling items seem to be running the risk of being over-shadowed by those of a rival firm.

If the manufacturer is unable himself, or through outside suppliers, to construct the required machinery in the given time, he must resort to less satisfactory solutions, to less comprehensive machines than those with a greater degree of automation. Sometimes he

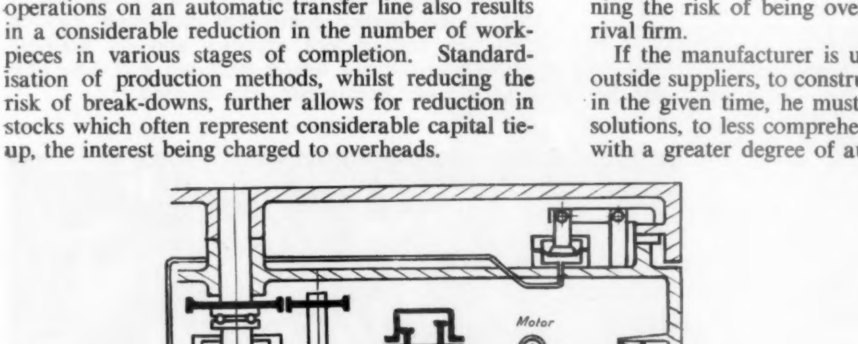


Fig. 14. Mechanically operated Renault turntable with interlocked pneumatic drive.

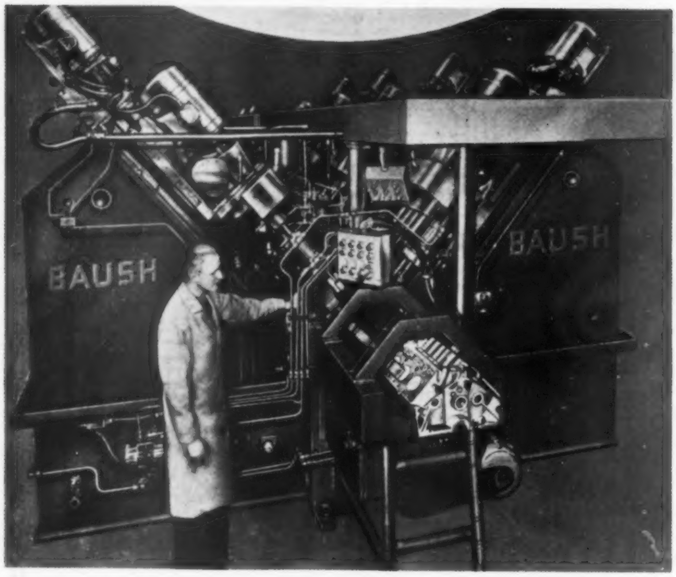


Fig. 15. Baush non-platen transfer machine for processing cylinder blocks.

must find ample provisional methods, with the intention of replacing these at a later date when time and conditions allow of finality.

Design of the Component to be Manufactured

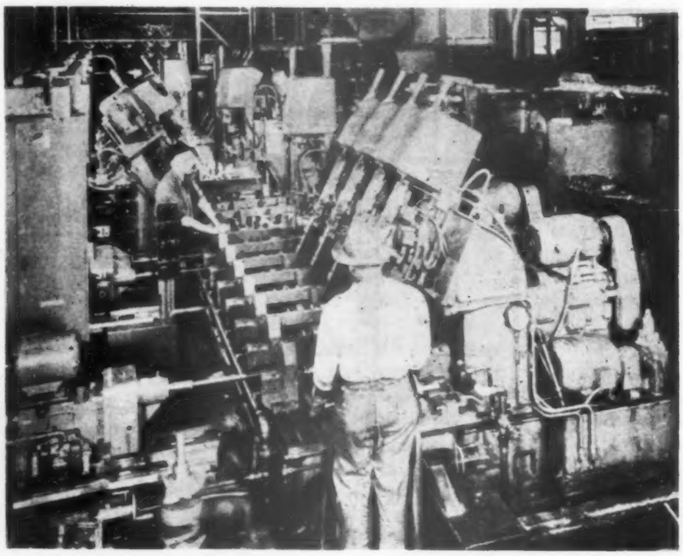
When the management authorises expenditure for initial outlay, the determination of equipment enters into the definitive stage, and plant and fabrication departments must try to reach the lowest cost-recovery price without altering the quality of the product.

Economies on the Original Materials

The choice of materials is determined by the experience of the drawing office. It is very seldom that later tests result in any substantial reduction in the value of materials originally used. On the other hand, process planning often results in a reduction of the quantity of the material used at first and thus are obtained economies in metal fabrication, forging or foundry work.

If the shape of the rough part is sufficiently near to that of the finished component economies may be made on cutting tool expenses and on finishing labour. In this case lighter machines, and those of a much reduced hourly rate, may be used.

Fig. 16. Kruger & Snyder non-platen transfer machine for processing crankshafts.



Economy on the Shape of the Components

The designed form of the component directly influences the number of machining operations required and likewise the price of the machines involved. It is easily conceivable that the price of a machine for processing a flat or cylindrical surface is lower than that of a machine used for generating helical or spiral bevel gears.

During this examination planning may need to suggest modifications to the shape or positioning of the surfaces to be machined. Sometimes millimetres make the difference between the efficiency of a broaching and a milling operation, or between hobbing, and cutting, which is a much slower operation.

Economies deriving from Greater Precision

The finer the tolerances to be maintained, the more frequent the adjustments and difficult the maintenance; this may lead to the risk of increasing quantities of rejects.

We have many discussions between the design and building departments, since the scattering of the machines sometimes prejudices the accuracy of the required tolerances, and one has to resort to more difficult pairing.

The D.O. should be kept informed of the current building methods, in order that designs be in accord with the usual manufacturing methods.

Bank and Float Stock Amounts

When a production line is formed, sufficient stock must be maintained between each machine to ensure the time cycle by the minimum of personnel movement.

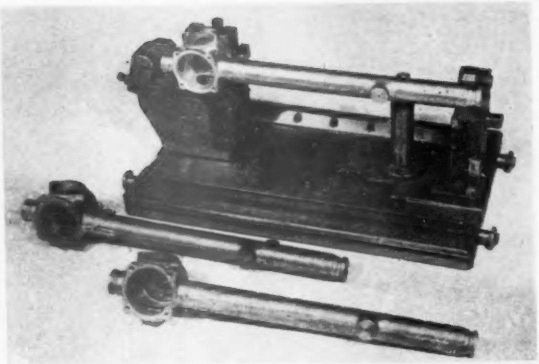


Fig. 17. 4 h.p. Renault steering box fixed on transfer machine platen.

Moreover, the shop manager does not relish the responsibility for any stoppage, tending rather to build up necessary stocks to cover any breakdown in production.

Automatic line production naturally obviates waiting stocks; whilst it is much easier to keep statistics of stoppages on special machines, and from these to fix the amount of stock required, thus balancing the costs involved with the risks resultant upon stock reduction. It is here that quality control finds one of its applications. If automation helps to keep a check on stoppages, standardisation of machine parts reduces their inconvenience.

The reabsorption of current stocks, when automatic machines come into service, has often allowed us to

Fig. 18. Renault transfer machine — return conveyor.

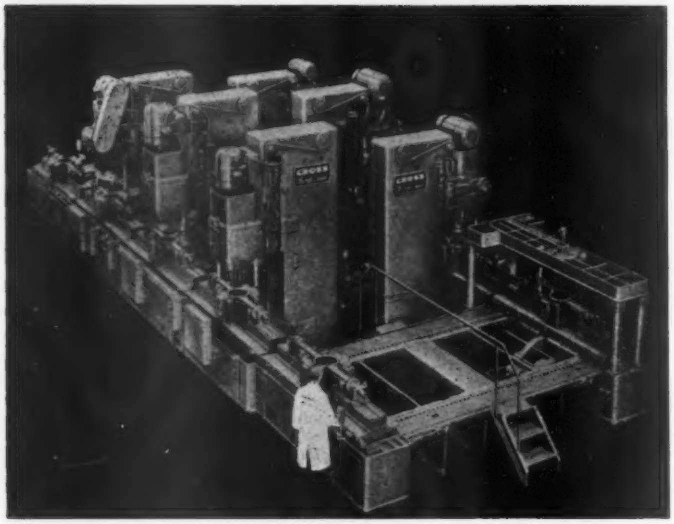


Fig. 19. Cross transfer machine.

make economies which are considerable when taken in relation with new tooling.

Swarf and Waste Material Control

To ease swarf collection we have often installed channels below the machines. According to its nature the swarf is removed from these channels by scraper chains, rakes or a stream of liquid. These channels also collect the coolant, which goes to a central filtering station, is asepticised and returned to the machine by a pumping station.

The degree of economy required from automatic swarf clearance has resulted in an important alteration in the layout of the workshops; whereas it was practice to install the machining lines in the component production sequence, we are now obliged to place together those lines machining the same material, since different types of swarf obviously cannot be mixed.

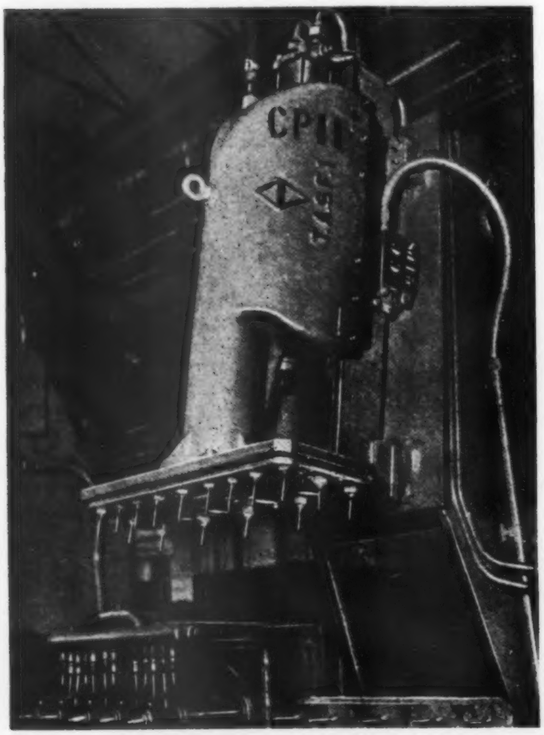


Fig. 20. Renault control unit.

Downtimes

The more expensive the plant, the less time it must remain idle.

Loading

Loading times are eliminated from the automatic transfer cycle since this operation is effected during machining. Indexing time is not more than a few seconds.

Automatic clamping devices reduce the loading times in such a way that one workman may be entrusted with the unloading of the finished component, the cleaning of the fixture, and the loading of the workpiece.

Since transfer machines often use several dozen identical fixtures, they may be made in bulk and fitted with automatic controls without unduly increasing their price.

The eventual aim in the evolution of this type of machine is one where loading and clamping is effected without human intervention in the cycle.

Such devices have long existed for handling articles of regular shape; all the cutting off, and nut and bolt processes make great use of them. Non-platen transfer machines often attain this degree of perfection, but it is not impossible on platen-type machines.

Fig. 21. "Telemecanique" control desk for Renault transfer machine.

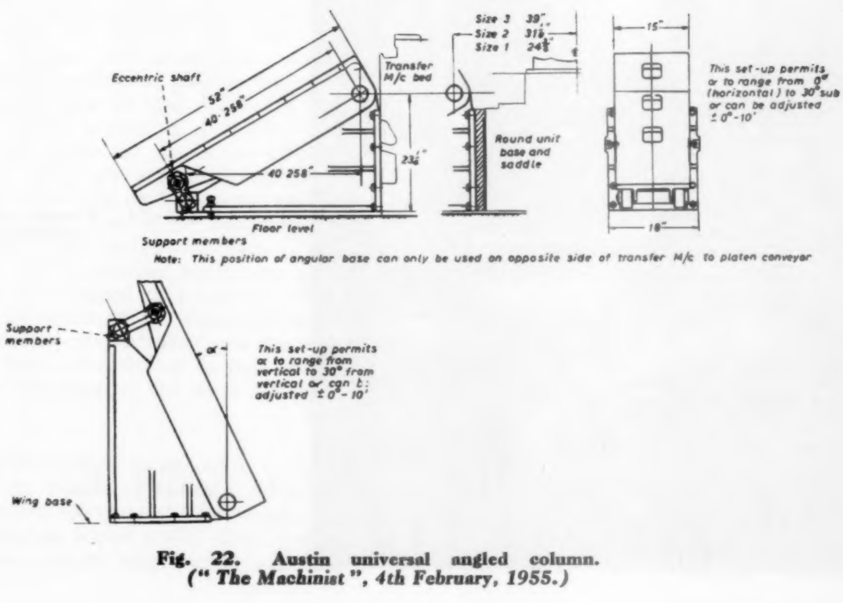


Fig. 22. Austin universal angled column.
(" *The Machinist* ", *4th February, 1955.*)

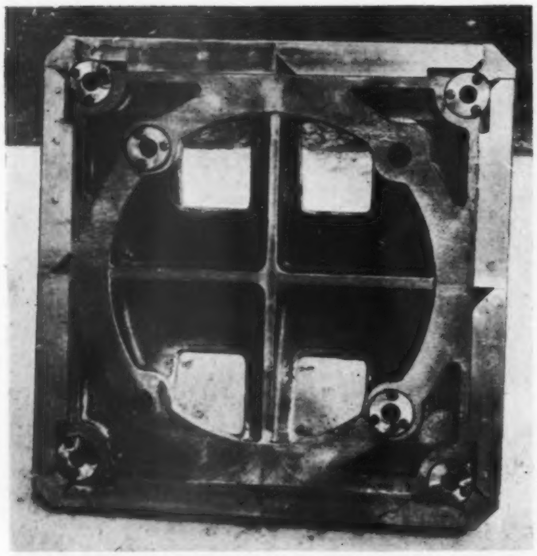


Fig. 23. Underside view of Renault transfer machine fixture platen. The 2 sets of outer bushes locate the fixture at 90°. The inner bushes locate at the indexing station.

Tool Breakage

If the machine works without supervision, checking devices are required to stop the machine if all the precision and safety requirements are not fulfilled.

Certain mechanisms ensure that the tools are in a good condition and that the normal working condition of the various parts is maintained; control units check the depth of the holes before reaming or tapping, and ensure that fragments of broken tools do not remain in the holes (Fig. 20).

If these conditions are not fulfilled the machine stops and the cause is shown by a light on the controls (Fig. 21).

When tools of less than 22 m.m. dia. are in use, the control gauge would be very fragile and sometimes it is preferable to check the condition of the tool with a wire feeler which is moved into position when the tool leaves the workpiece; the contact between the wire and the tool acts upon an electrical or electronic device which allows the machine cycle to continue.

Tool changing is the normal cause of machine stoppages. Some users have a tool changing programme; others, with whom we are in agreement, think that the variations in the quality of cutting tools and in the hardness of the metal which is being worked, may appreciably vary the frequency of economic tool changing.

Under present conditions we prefer to depend upon the care and integrity of the operator, who may be entrusted to hasten or delay tool changing according to the time theoretically laid down.

Technical Considerations

Method of Working

In certain countries the special purpose machine industry is highly developed. This is so particularly in the U.S.A. where there are about thirty manufac-

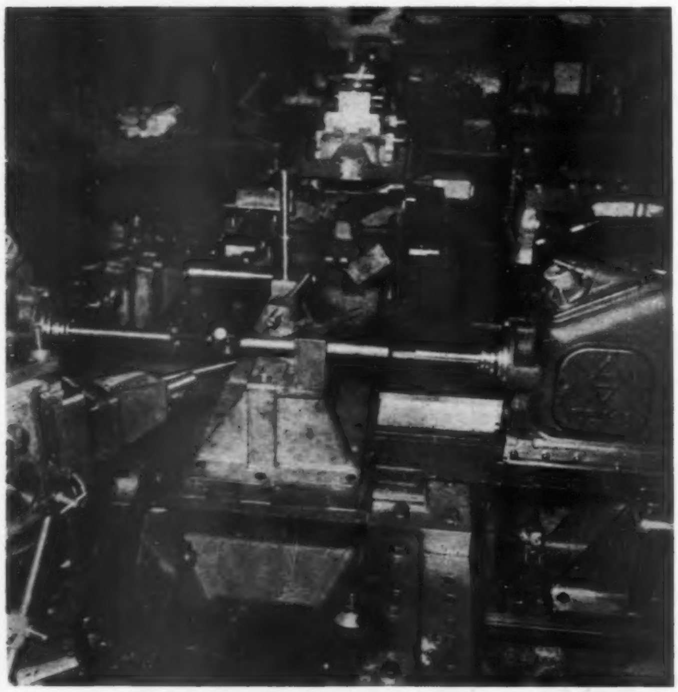


Fig. 24. Renault unit in course of adjustment.

turers with 25,000 employees, but despite its size, this industry is often overwhelmed with orders from a few customers, whilst others have to delay their new programmes.

On the other hand two important European users, Austin and Renault, have both built a number of special machines for their own use. Their preference was for worm-driven units, at a time when other producers in their respective countries built little else but hydraulically-driven units.

The design of such plant calls into action extremely varied techniques, and the requirements of the D.O. must be in accord with present or future construction facilities.

The complete range of indispensable additional operations such as location, depth control, and cleaning must be taken into account. This latter point is much more important than would appear at first sight; all swarf in the recesses must be removed, and oxidation after washing be checked, especially if the component remains in the washing station during the weekly non-working periods.

Control and location checks are of necessity also affected.

Liaison with the D.O.

As the machine designs progress the D.O. is constantly being consulted, since it is impossible for them to foresee all the machining difficulties which may arise, or to be fully up to date with the latest materials at their disposal.

Tolerances

One of the most important points is the primary consideration of tolerances. We all know how costs for an operation increase, whilst relative tolerances decrease. It is extremely important to determine the maximum tolerance compatible with satisfactory functioning of the equipment to be made. This is difficult to do during the construction of prototypes, since lengthy tests are required for many varied dimensions on different parts of multiple assemblies. Too much attention cannot be paid to these points.

It is interesting to note an idea which has become general in the light of experience of quality control. It is thought that when the dispersion of the two parts of an assembly are separately subjected to Gauss' law, the dispersion on both parts together is equal to the quadratic sum of the two original dispersions, and not to the arithmetical sum.

This requires the measuring equipment and the machines to be so designed that anything likely to affect the difficult nature of the dispersion be eliminated. In particular all graduations on the measuring equipment must be removed so that one index remains in correspondence to the main dimension.

Shape

The shape of the workpieces should be so carefully developed that the benefit of technical advantage is gained, and process planning should negotiate with the D.O. any changes which would simplify machining. Sometimes a slight modification will lead to considerable economies; several examples may be instanced: where two teeth are too closely placed on the same gear, that gear may be hobbed if the teeth are spaced further apart; a hyperboloid cutter may be used to shave the gears if the machine is made for this type of tool; if a clutch plate is spur or plain a normal Fellows, Shear Speed, etc., or a special machine, may be used; machining of an external groove on a fixed workpiece necessitates a special boring bar with recessing tools, while if it is transferred to an arbor, machining becomes very easy; the radii in the angle of ground bosses require special former or radius trimming devices, whilst the grinder, or lathe rough radius allowance recess would allow a square slide trimming device

Liaison with Plant D.O.

During the installation of a set of machines in an existing building, allowance must be made for the type of building, height below girders, the possibility of installing crane beams to ease machine assembly, or the repair and maintenance of certain very heavy tools (broaches or grinding wheels).

The swarf channels must run parallel with the machines in the direction of the outlet, and should not be deep enough to require the installation of syphons.

The strength of the girders also determines the possibility of installing aerial conveyor belts.

The size of the conveyor tubes, the trolleys or trailers determines the width of the gangways.

Sometimes certain types of machines may be centered around a refining or liquid distribution point, as is particularly the case with grinders.

Likewise machines with a fire risk — largely due to the use of hydrocarbons as cutting liquids (kerosene, paraffin) — are grouped in a specially protected area.

Machine Design

It is impossible to describe in a few words the task of special-machine draughtsmen. Since many of them spend a lifetime at the job, a Conference such as this has insufficient time for such an account.

Let us say, however, that these draughtsmen must maintain an ever lively critical approach to their work. The delays in manufacture and assembly attributed to them are always very short, and one must be careful because rushed and spoiled work is hardly pardonable.

Whilst having enthusiasm for his work, the designer must be clear-headed, and seek the simplest and safest answers

Standardisation must be his continual care, rather than the search for the brilliant solution to an isolated problem. As an example, we have the machining units, which must have the primary quality of being an easy solution to very varied problems, even if they do not exactly cover every one of the possible problems.

All standardisation involves obligations, but equally certain are the considerable advantages it brings with it — recovery costs, building delays and

the possibility of making up for them, and one cannot make too many sacrifices in this direction.

In an industry such as ours, which is subject to alterations in design, it is most important that a large part of the machinery be recoverable when one model is discontinued, and used in the production of new models.

The economy is equally considerable when the design and building delays of our machines are examined; by using standard elements we have been able to design rather complex machines in less than 150 hours and due to existing stocks to deliver them sometimes within about two months.

Certain parts of the multi-heads have been standardised so that they may be pre-machined and put into stock in advance of requirements; the Author's Company have in stock a good number of main body castings for three or four different types, which themselves cover a large part of our own needs. The multi-head spindles are strictly standardised, with of course the reservation of the gears, the design of which must adhere to the inter axes required.

Some special machine manufacturers case all their main bed sections. We do not follow this practice except where quantities are required; the purchase of a pattern is then justified and delays do not result since the rough or machined parts may be held in stock. In Fig. 22 is seen a universal angled column used on the Austin machines.

However, where these beds are made for special requirements, welded beds are used; by this method, it is thought that the Company benefits in regard to both price and speed of fabrication.

Some makers hesitate to use these welded beds because they seem to them more subject to vibration and bending than cast beds. We think it a design matter, and even for ourselves we have made welded beds for millers; in the U.S.A. large brackets are in use on similar beds.

Co-ordination

Very varied knowledge is called into play in the design of these machines. Co-ordination between the various technical departments is ensured in our factory by planning, and more particularly by the Plant Dept. This department receives the general plans of the machines from the D.O. and after deciding upon their position with due consideration of such matters as girders, the ground, drainage, they can plan aerial conveyors, central refining and liquid distribution points, swarf removal stations, machine foundations, etc.

It seemed to us that this was the best department to concern itself with the plant and workshop design, and to avoid loss of time by work spreading. It is also their responsibility to liaise with the fabrication departments whose advice is sought when a project is sufficiently advanced for all those departments who are interested to be consulted on details and their completion.

Building of Machines

Although it is very rare that many special machines are identical, their fabrication belongs more to the large batch idea than to the "one off" method, since it is imperative that reduction to the minimum building cost be kept in mind, and that perfect interchangeability between all parts of these machines be ensured. In short, it is important that any repair may be done in the minimum of time, from parts made and adjusted in advance, so that lengthy delays likely to interrupt production do not occur on the production lines. Operations such as scraping, fitting, adjusting and checking should be reduced to the minimum. The interchangeability of machine parts is equally indispensable when certain of them are salvaged for re-use on new model production lines. It is thus that the Company have discontinued the use of dowelling plugs for transfer machines with fixtures, the play between the bushes and the boring bars not being in accord with the precision between the axes. All transfer machine parts are processed on jig borers. This solution, although somewhat more inconvenient, is the only one which will allow of interchangeability and recovery of constituent parts. On the other hand it considerably shortens the adjustment time for the machine.

Machining and Handling Units

These are batch produced and the problem of interchangeability is resolved as in all batch production by the use of machining fixtures, checking and control gauges.

Fixtures

The Company's transfer machines sometimes use more than 100 fixtures. When these fixtures have to accommodate rough workpieces, it is not indispensable for them all to be absolutely identical; but if the workpiece has to be located by previously machined surfaces they must be machined by tolerances of the order $\pm.01$ m.m.; we are thus sometimes forced to machine these fixtures roughly, whilst ensuring their identity. For each batch of fixtures leaving the workshops, a sample is kept to which reference is made in case of the necessity to re-machine an existing fixture or to build a new one. All fixtures have tempered resting points for the work pieces, and the resting points for those fixtures moving on the transfer slides are also hardened (Fig. 23).

Bridge Fixtures

The transfer machine elements have dowel housings placed at an exact distance from the fixture location dowels, in such a way that the bush plates for guiding the tools are made on the jig borers and do not need to be retouched on assembly. This process allows a considerable reduction in time for adjusting the machine, and it also facilitates modifications on the machine during the production period if required, this with the minimum interruption of work.

Multi-Heads

All the multi-head main bodies are jig bored and we attempt to maintain inter-axial tolerances to plus or minus 0.01 mm. This tolerance is often much

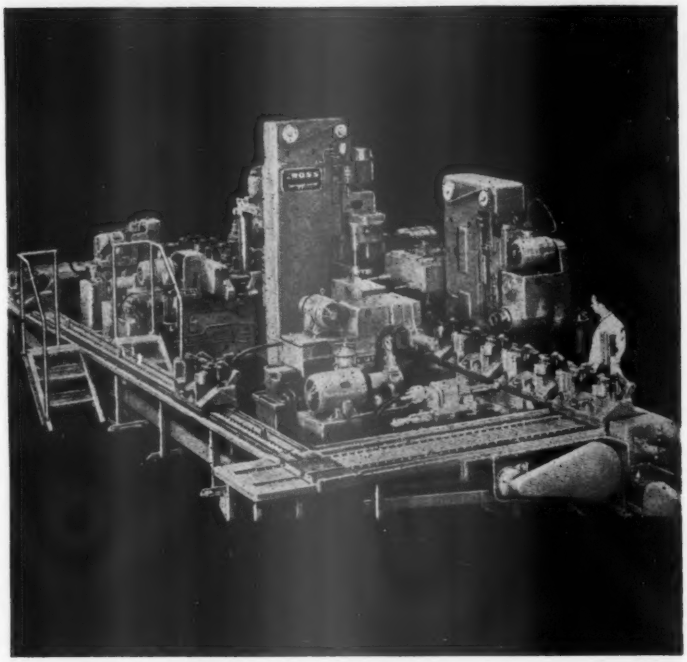


Fig. 25. Cross transfer machine. The clamping mechanism is at the first L.H. station.

closer than required by the Drawing Office, but we do not envisage modifying or replacing a head whilst it is working without being absolutely sure that it is identical with other heads performing similar operations. Whatever the tolerance between the axes of the work pieces, it is most important that the drilling, reaming and tapping heads be identical if good tool life is required.

Assembly and Adjustment

When the above machining tolerances are maintained machine assembly is considerably simplified. However, certain parts cannot be completed on assembly and require some adjustment.

Main Beds

Several American builders process their main beds, brackets, and columns, on large planing or grinding machines. The amount of material to be removed during retouching is determined during the course of a preliminary trial run. For our requirements, due perhaps to lack of high precision or large machines, we prefer to determine on assembly the thickness of the ground spacers to be placed between the main beds and the units they support. Sometimes, whilst small sized units not subjected to heavy strain are in use, they are mounted on levelling jacks. When the ground on which the machines are installed is not too stable, these jacks are useful for realigning the machines.

Units

Mounting of units is relatively easy when working with bush plate bridges. A comparator is sufficient check that the ends of the spindles are in the shanks provisionally mounted in the bushes. Units working without bush plates, units for instance performing chamfering or tapping operations, are positioned in relation to specially made standards which have the assembly locating holes and the reamed holes corresponding to the main holes on the workpieces (Fig. 24). This standard is kept in the workshops and is used whenever a unit has to be readjusted.

Use of Machines

Many people have remarked that these machines are expensive; their hourly cost return represents a rate several times that of the operator; thus non-working times are to be reduced as much as possible.

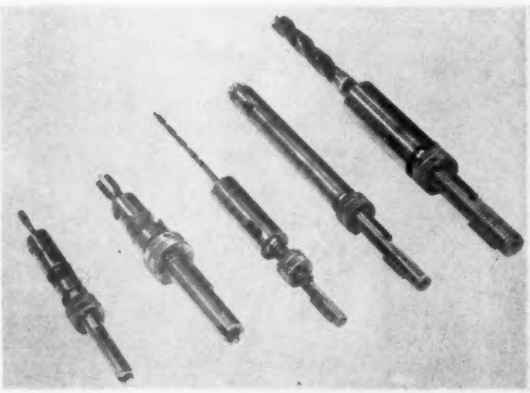


Fig. 26. Tools in adjustable extension pieces.

Fig. 27. Renault transfer machine with washing station on return conveyor.

Loading and Unloading of Workpieces

It is of primary importance that the handling time for unloading the finished component, the cleaning time for fixture, and the loading of new workpiece does not exceed the time allowed for the cycle: the present tendency is to make the clamping operations increasingly automatic either by spring washer devices, non-auto locking screws, or even an automatic locking screw on the first station of the machine (Fig. 25). It is important that the rough shape of the workpieces be as regular as possible so that they may be put into place with the least difficulty and without appreciably altering the clamps. The use of fast clamping equipment such as wedges or cams requires regularity in the size of the rough workpieces. While it is not possible to obtain this, multi-clamping devices must be used to accommodate the extra thicknesses; however, we often prefer previous machining on standard machines, thus allowing ourselves an easier task as far as the number of automatic fixtures are concerned.

Periodic Tool Changing

This constitutes an important part of the down time for automatic machines which is often to the degree of 20 per cent. of the working time. To lessen this, the tools are put into position after truing in the extension pieces, so that the distance between the cutting stop and the shoulder of the tool may be determined in advance, thus eliminating all adjustment on assembly on the machine (Fig. 26). For the same reason building multi-heads where the spindles are extremely close together is avoided, for not only does this weaken them, but also difficulty of assembly and stripping down would be experienced. All large multi-heads have been equipped with a non-automatic spindle positioning device which eliminates motor jogging, and draws the clamping screws into a convenient adjustment position. Moreover, where all spindles of a multi-head are turning at the same speed we have arranged that all clamping screws are equally accessible.

Tool Breakage

Despite periodic tool changing, breakages sometime occur. In order that this does not prejudice the good quality of the other tools, checking stations have been provided on the machines where, with the aid of depth control feelers we can check the holes. At the same time this ensures that pieces of broken tool are not still in the hole. In the case of blind holes these feelers are hollowed to allow a jet of compressed air to pass through and blow out any remaining swarf. Reaming and tapping operations may then proceed with complete safety (see previous section on " Tool Breakage ").

Washing

It is important that the components and the fixtures be washed after the operation is completed. In certain cases this is performed at a washing station in the form of a tunnel on the fixture return conveyor (Fig. 27). However, since this increases

the area of the machine and requires additional installations for collecting the washing liquid and the swarf, we now prefer to place the washing station immediately before the exit from the machine. This consists of a drum which completely rotates the components and the fixtures so that a jet of liquid may wash away the swarf (Fig. 28). It would be preferable to dry the fixture by an air jet before returning it to the entry station, but up to the present we have not included this additional expense.

Maintenance

Lubrication

The shop in which the machine is used must ensure that the maintenance staff keep the machine in an efficient working condition. An important part of this work is instanced by the replacement of the guide bushes.

Each machine has two or three additional fixtures in order that the others may be periodically overhauled in their turn.

The lubrication of these machines is the particular occupation of one specialist in this type of work, and in our factories the fabrication shops are responsible; the tendency in the U.S.A. on the other hand is to make this the responsibility of the maintenance staff. If lack of lubrication prejudices the life of the machine, excessive supplies of it lead to heating of the moving parts, which inevitably results in considerable oil losses.

To remedy this fault, oil-mist lubrication has been used on all machines in the Author's Company. Every part requiring lubrication, the unit, the multiple head, etc., has an auxiliary reservoir containing approximately one pint of oil. A closed circuit compressor forces air into the nozzles at 4 p.s.i. taking oil from each reservoir. This device allows reduction of the working temperature for the machines and reduces oil consumption to a considerable degree.

Prevention and Care

The maintenance department pay periodic visits to the machines and by preventive methods it is hoped to avoid major breakdowns which would result in costly repairs and reduction in the machining times. The function of the Superintendent is very important here since he is constantly with the machines and can immediately call in the maintenance staff when he suspects trouble such as noise, heating, wear, and lack of oil, etc.

Replacements

Special Parts, Fixtures and Multi-Heads

To reduce stoppages due to accidents to a minimum, the Stores maintain a small stock of replacement fixtures as well as of the most fragile multi-heads.

The standardisation of the spindles of the latter allows us to reduce the replacement of a multi-head from the complete item to the broken gears. Since these parts are made in a semi-hard steel, heat treatment is not required during manufacture, and thus in times of need they may be machined very quickly.

Standard Elements

The units were designed to be extremely robust and to ensure trustworthy service. Such repairs or

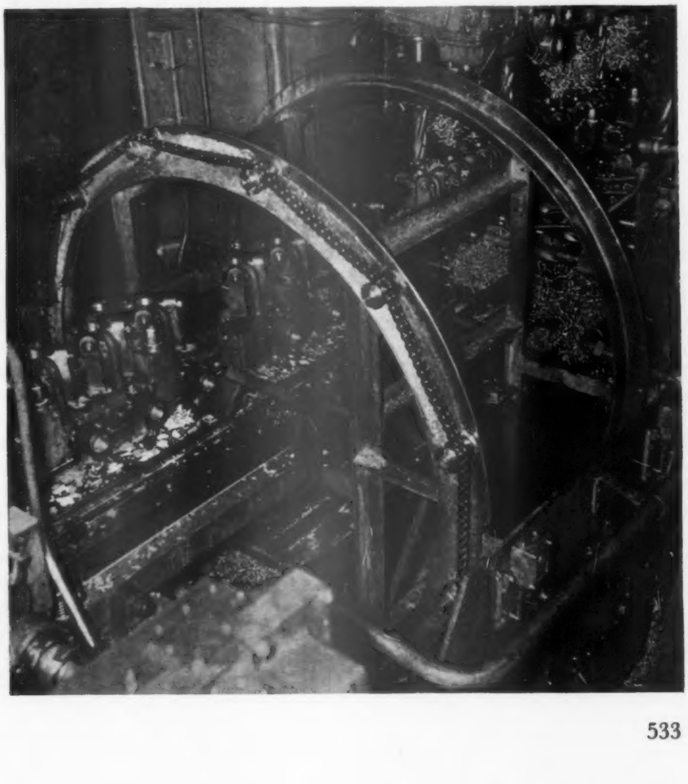


Fig. 28. Washing and tipping station included on Renault transfer machine. Guards removed.

Fig. 29. Pulley and pneumatic clamp at exist station of Renault transfer machine for processing "Fregate" crankshafts.

replacements as have had to be made are limited to changing *in situ* a gearing or a gear, and in ten years of use it has never been necessary to change a complete unit. By reason of the extreme standardisation under which the work is done the Company have limited themselves to three models of machining units (one, three and ten KW power) and two types of transfer line elements (560 or 320 mm. width). All these mechanisms are thus perfectly well known to the maintenance staff, and at present failures are repaired with a minimum of delay. The change of a multi-head or the modification of a machine will often involve the removal of assemblies weighing several hundred kilogrammes. With this in mind, all the transfer machines have an overhead hand-controlled crane; this considerably eases machine adjustment and lessens time wasted on stoppages. This type of crane is preferred to gantry cranes.

Manpower Problems

A workshop equipped with transfer machines has a completely different appearance from that of a machine shop of twenty years ago. Then it was instinctively thought that the development of a new and more complicated technique necessarily required more widely experienced personnel, which would in turn result in recruitment or organisation difficulties. On the other hand it may be believed that these more automatic machines might require many specialists to adjust and maintain them for the same production level.

Direct Manpower

When one considers the requirements for a worker in charge of a standard or special machine, one discovers that the amount of work required of him is more or less the same. It is no more difficult to place a workpiece in a fixture when this belongs to a special machine, than to do the same when it is fixed on a drilling or milling machine table. As for present intellectual effort, it is no more intense since the special machines are equipped with safety devices which will check incorrect setting. We have seen that controls also check tool condition.

The difference lies especially in the increase in the operator's moral responsibility, for lack of attention may lead to very damaging effects to the special machine mechanisms, much more so than to those of standard machines where the price is but an infinite part of that of the special machine. One has to depend upon the attention of the operator to detect any imminent failure of his safety devices and thus prevent a severe accident.

To allow him to give his full attention to the working of the machine increasing care is being taken to avoid all physical fatigue. Where components weigh more than about 10 kgs. the loading and unloading stations are equipped with pneumatic hoists, and where clamping and unclamping operations involve heavy muscular effort, the stations are equipped with pneumatic clamps (Fig. 29). The Author's Company will not hesitate in the future to equip certain of their machines with automatic loading and clamping devices.

(*concluded on page* 516)

AUTOMATION—
SOME PROBLEMS FOR THE BOARDROOM

by M. SEAMAN, M.Sc., M.I.Mech.E., M.I.Prod.E.

Mr. Seaman, after graduating in Electrical Engineering at Manchester University, was Research Fellow and Lecturer in Engineering and Management at the University. On entering industry he became Assistant Works Manager with Ferranti, Ltd. and, subsequently, Production Manager of David Brown & Sons, Ltd. at Penistone.

In the early stages of the War he took over the manufacturing side of Newton Chambers & Company, as General Works Manager, and was responsible for their major reorganisation and war production until 1945. He returned to the David Brown Group as Director and General Manager of David Brown (Jackson) Ltd., and in 1950 joined The British Oxygen Company, Ltd. as Director and General Manager of B.O.E. Ltd., the principal engineering associate company of the B.O.C. Group.

Mr. Seaman has served on a number of Ministry of Supply committees, and has been a member of the Council of the Institution for several years. He has undertaken various missions both at home and in various parts of the world for his own Companies and for the Government.

Mr. Seaman

WITHIN the welter of investigation of the many specialist factors of automation and automatic production unit operations which are now being carried out there is, I believe, room for applying ourselves to the considerations which can be best seen from the point of view of the Boardroom of any operating unit. It is, at this level, that the widest considerations have to be met and decisions of lasting effect for the future made. As these in turn must be worked into the main social fabric of the nation, and even be balanced with international considerations, it is wise for us to state some of the primary considerations and problems which arise.

The Two Main Categories of Automation

Automation, in the accepted modern sense, probably dates from the early years of the twentieth century and has now reached the stage by mid-century when the rate of development is reaching geometric proportions in terms of the possibilities and the incentive for application in the world at large. It is important to distinguish between the two main categories of automation, and these are :-

1. Process Controls.
2. Automatic Production or Service Operations.

1. Process Controls

Process controls may be divided into :

(a) Clerical Operations
(b) Technical Operations.

We have seen very marked increases in the potential equipment in the clerical operation controls. Their main character, based upon electrical and mechanical devices, is the feeding of information found to be necessary in the clerical control of the business and the linkage of these control processes with the flow of manufacturing and operation activities in such a way that these synchronize with the changing situation from second-to-second. The labour-saving characteristic of the clerical automation revealed itself primarily in the synchronization of information and control action with the flow of operations. This results in a reduction of the required volume of clerical information with the inherent man-hour savings as against non-mechanized clerical operations.

Two forces conflict within this primary concept; the ideal process manufacture which in itself is technically controllable without human aid from beginning to end can, in many cases, dispense with considerable amounts of the normal clerical flow of variable operations. Only significant cost and techni-

cal factors need to be recorded and linked for action with the flow, and presuming constancy of the product and its creation, recorded clerical work is progressively reduced to the final ideal of beginning and end measurements and balancing. The potentials in this direction are quite self-evident and the coalescence of clerical, technical, and automatic production control is quite clear. The economic virtue of this system is that human controls are not required except in the higher sense, and there is a considerable saving of national man-hours and Company man-hours which can be deflected from the manufacturing processes to the manufacturing equipment operations, with the result that capital cost, plus conversion cost, is considerably improved under the conception of higher total productivity. The need for constancy of product and total efficiency of control is fundamental to this type of operation and where the product or the service lies in line with these concepts, the Management Group have no difficulty in seeing its virtues and taking direct personnel and development action to secure the greatest benefits both to the Company and, therefore, to the nation. The basis of higher productivity within the concept of full employment rationalises and clears any tensions between the Company and the social acceptance of these arrangements.

Process Control with High Inherent Variations

The opposite pole of concept to the above case is the "Jobbing" shop where considerably minute-by-minute adaptations have to be made because of changing demands, technical content, and form. It is often argued on this other limit case that automation of any degree in clerical control becomes so inflexible as to represent a reduction in efficiency, but a Board must be aware that this is not necessarily true. The fact is, that presuming the physical disposition of the factors of production and service in the right order, and principles of coding and control designs specifically to give simplicity and effectiveness, then a considerable measure of automatic and semi-automatic control operations can be brought into effect in a small firm jobbing concept. Sufficient attention has never been paid to the total factory design basis in which the combination of the operations and the control procedure is highly facilitated within the concept of measuring and controlling only those things which are worth doing. There has been much progress made in this field in the past quarter century, and extraordinary degrees of flexibility with automatic operations of control have been secured.

Clerical Control Procedures (General)

Between these two opposing pole cases every possible variation exists and must be applied. The constant factor is the relative inflexibility of the mechanised control processes unless high speed timing action is taken on the feed information, and where this type of simplification is done, very marked total productivity advantages accrue. This is an extremely fruitful field which any Board would do well to pursue at any potential stage of development operations.

2. Automatic Conversion Operations

The general study of knowledge on this subject, together with the intensive attention being paid to various aspects of this subject at this Conference, make it unnecessary to define the technical aspects of this general problem. I shall, therefore, confine my observations to the primary policy factors upon which the main foundations are based. These are:

(i) product development variation;
(ii) development and capital ratios;
(iii) sales circulation dynamics in relation to the total market.

(i) *Product Development Variation*

All new products arise from the drive of a primary concept of a new product or service which will ultimately take its place in the product or service structure of a nation. The drive force is an unique imagination of the potential of a device or service and requires courage and perception to bring to fruition. Most Board policies must, therefore, be self-reliant in their judgement on these matters, and their total development structure consists of the sum of these ideas and their successful fruition. Therefore, according to the technological potential of the period an increasing number of developments, products, or services are fighting for successful application, and an effective system of control and administration is necessary to produce the best results. The natural selection of development, which is effective at this level, is generally to produce those which are the strongest over the longest period of time, i.e., will serve the largest portion of the population for the longest period without variation, and if successful technical and development engineering is put into products at this stage then a certain degree of stability of product can emerge with advantage to the Company and to the community.

It is, however, true, and many case histories are on record, where advancing technical levels constantly produce problems which turn an apparently stable probability into something requiring radical alteration, and this can be one of the main headaches of development programmes in relation to automation low cost production, and service.

I think it is true that, at this stage, a certain amount of social balancing with the competitive structure is inevitably carried out within the various units. To presume the absurd commercial case it could happen that constant awareness of possible development could give rise to no fruition of any particular design of product or service, with inevitable bankruptcy and, therefore, the introduction of improvements in products, together with the elements of low cost production consequent upon these, is balanced out by timing to give a satisfactory relation between total development cost, capital employed, sales and profits from which further progress can be financed.

The Board of an operating unit, of whatever character, tends to be the organ of management in which these issues are resolved in the interests of sound financial and sales operations. The satisfactoriness of this overall aspect of policy is generally dominated by the relative velocities in the

sales field of national and international competition.

Human limitations and commercial policy both tend to give a reasonably satisfactory answer, provided that a Company or nation satisfies itself that its relative position both in rate and timing is not deteriorating.

(ii) *Development and Capital Ratios*

The main measure of the above problems becomes apparent in the capital and development expenditure ratio of a Company. The Board develops an awareness of its relative position in its own field and stages its capital and development operations in line with these and, under certain conditions, a fairly defined long-term pattern emerges. This pattern is apt to be changed mainly by technological considerations. The potential of new technological information becomes the driving force which, available to different units, may be used in different ways. Foresight and drive will then create an advantage which has to be matched by increasing capital risk and increasing development risk. It is, of course, clear in the modern Company and national operations that the most significant feature of the present age is the increasingly higher ratio of commitment of development expenditure in every possible field, and the increasing ratio of skilled technical man-hours and craft and service man-hours which have to be devoted to this problem because of its higher technological rate of change.

Judgement is made at Board level on the above subjects, and by Board I include all the National Management units which make decisions in this field. It is, of course, true that on at least 40% of our total expenditure on development, the decisions are made through Government channels from which Board decisions in this field derive.

(iii) *Sales Circulation Dynamics*

I want to suggest here as simply as possible that the whole of the subject which we are discussing is dominated in the last analysis by the sales rate of change within a community or internationally. A community may decide to be satisfied with a particular level and type of product for twenty years. If the sales dynamic is geared to this concept then it will have its obvious repercussions on the rate of change in the fields which we are covering. If the same community is geared to changing its consumption every five years, then quite obviously a totally different situation is created, the net result of which is that the ratio of capital to development expenditure is considerably increased probably in geometric rates of progression, and the whole velocity of the structure responds to the dominant drive for higher productivity. There is, therefore, a very close relation between the sales dynamic and the annual increment of productivity, totally measured within a nation or Company, of a product. Quite simply, comparative studies of increments of production have shown that in certain highly developed Western countries the increment of productivity has been as high as 5% whereas in an apparently similar country, from the point of view of technical production power, the annual increment of productivity has been as low as 1½% per annum. Whilst many explanations have been put forward for this phenomenon, it can be best summarised by the fact that if a nation or a Company decides to double its standard of living in a given period of years, it can do so. It can equally, with no target perception in this field, fail to make the necessary relative progress, and the dynamic of sales tends to be the force creating this situation.

3. General Conclusion

1. The tendency to further automatic control and production reduces cost, therefore increases standard of living.
2. Product variation unless sensibly controlled may tend to increase costs.
3. The balance between these considerations, at an effective level, can produce the inevitable progression of maximum total sales, minimum costs, financing of further maximum sales, further reduction of costs. It is the clearly demonstrated truth of this last statement over the past fifty years, which has made, and will further increase our tempo in this field.

The Case History of Automatic Production

1. At the level of the Boardroom, the total features of the above concepts become clear. Risk is taken in decisions upon a certain presumption of stability. Stability rests upon standardisation. and standardisation is effective for a period proportionally to the sales cycle.
2. The technical situation in many case histories gives rise to certain major standardisation units. These units, from a technical automation point of view, have then to be considered in combination, and this combination of units can give rise to a certain stability of capital and development ratios.
3. It is important to realise that product and production development go very closely hand-in-hand, so that in the total costing of an operating unit due regard must be made of the full measure of production development in association with product development.

These three major considerations dominate much of the thought which affects decisions in this field in relation to the whole, and a good deal of technique has been developed. These are based upon :

(a) comparative techniques on products;
(b) the highest common flexibility of means of processes and production;
(c) the long term planning of the above combination to give the best result.

4. Creation of the Right Attitude of Mind Within the Company

As it is of increasing importance within modern operations to carry every man and woman of the organisation with the Company's policy, Personnel Departments are required to study company policies as a whole, and place these in the right perspective before the members of its staff. An awareness of the

general direction of a company's activities is, of course, fundamental to the satisfaction of the individual within a company structure, and it is required that the Company shall do a good job of work in this field. Most of you will be aware of the considerable effort which now goes into this field, especially where radical changes in technical production are occurring, and within technical staff. The relation of the company as a whole to national or international development becomes a matter which must have a skilled and constant treatment so that perspective, drive, and enthusiasm are maintained. The National and Company budgets often embody decisions to ensure progress by long term action. As the momentum of increasing productivity generally satisfies the present balance, this can be done satisfactorily. As we have seen from recent cases where the full fruits of improved and automatic operations have not been pursued, then a difficult situation can be created.

5. Ensuring the Benefits — Social and Human

The bugbear of automation as a word and concept has been assumption of "ant-hill" organisation of industry with the possibilities of reducing employment. The first benefit to be ensured to the workers or the members of any company from increasing product development and automation is an awareness of their increasing effectiveness in the general picture. This must be kept before them, and demonstrated in every possible way. It is essential that a Board takes care to ensure that every member of the team knows how the organisation as a whole works, and what his effective part is in it. The modern citizen knows more and more that the specialization of each man or woman creates the greatest degree of interdependence, and with the correct personnel policy this awareness can create a total field of satisfaction. This sense of total satisfaction will not occur spontaneously; it must be developed and cared for at all times.

6. Planning the Capital Transition Period

It must be frankly recognised that the planning of the capital transition period is something which, in the modern world, is entrusted to the Company and the National units of management.

In order to secure a certain level of progress in annual increment of productivity, the commitment of certain capital resources to development in higher and higher proportions becomes inevitable. Therefore, the ordinary process of saving must take place.

It is probable that despite rapid technological change the development capital ratios can always be satisfactorily accommodated, and provided the long term satisfaction of the earning population is made clear by frequent demonstration, no serious stress in the sharing out of the national consumption "cake" will be experienced. This possibility of tension, however, does put upon the Board of a Company and National Boards of management the necessity for making the implications of the capital transition period clear, and it is of course true that the practical results of management in this field have given rise to increasing satisfaction.

7. Combining Job, Leisure and Training

There is a natural balance between the above components of a human being's life, and I would suggest that one of the main significant calls on the whole of a Company's staff and, in fact, on the population in general of a particular country, is the necessity for increasing commitments in training, in order that each human being may adapt himself to the higher demands which the modern world makes upon him. It can be too easily assumed on the "ant-hill" analogue that the human progression in the modern world is to simpler and simpler jobs of less and less interest, i.e., a progression to full human automation. Nothing is further from the truth. In the modern developed technical world more and more people have to do more and more complex and responsible jobs requiring more training. This obviously means that their expressions, their full potential is more truly assured in the modern world with its automatic operation than in any previous era of existence. This fact deserves the fullest study, and the fullest expression in all levels of policy. It could be the basis upon which sales dynamic, i.e., greater purchasing power is established, and it can have its moral and intellectual counterpart.

Presuming therefore that a larger proportion of a human being's time must be devoted to training as a result of an advancing automatic world, a balance must be created from this potential position and the time expended in one's job and in one's leisure.

The series is, that training in techniques is essential to the performance of one's job, and the sum total of this combination will give high purchasing power, plus increased leisure. High purchasing power is a supreme expression of freedom of action in the world's markets, and leisure is the supreme expression of one's powers of creation and reflection and recreation.

I consider it worth saying that a balance between these three features is a matter for constant review by a Board. Whatever may be the temporary 'out of balance' of some of these features, the general drive and success of a nation depends upon their long term balance in the truest sense, and this therefore is again a problem requiring the best possible attention.

8. Ensuring Export of Benefits

The best way to visualise this problem is the Point Four declaration of ex-President Truman in regard to the export of technical benefits from highly developed to under developed countries, i.e., from high standard of living countries to low standard of living countries. The relation of this fact to the problem under discussion is that a highly developed country will tend to move most quickly to high degrees of automatic operation because of its high labour cost, but it is clearly true that the creation of semi-automatic and fully automatic plants will enable these to be exported to low standard of living countries, and operators may be trained easily in those countries to operate such plants. Now it is true that fear is often generated that such a process will result in danger to the standard of living of the high standard

of living country, but I suggest that this is not true. The creation of wealth by higher productivity will inevitably stimulate every type of demand by the conversion of dormant material into useful materials for consumption in the modern world. This increase in wealth, on a world scale, would, in the long run, tend to relieve tensions, and therefore in the social field the export of automatic operations and machinery can give rise to long term improvement in world consumption upon which the world levels and Company levels of trade depend.

This aspect, as it concerns a Board, is therefore related to their export operations both in the product sense and in the capital sense where plants and production capacity are established in other countries. You will all be aware therefore that the flow of capital and technical power to the under developed countries is one of the most important aspects of this problem, because in plants of increasing degrees of automation the speed of their effectiveness in wealth production is increased with its contribution to the reduction of tensions. I have of course excluded any political considerations in this connection, but it is quite obvious on the commercial and technical levels that this is a real feature of modern operations, and we could all quote a dozen cases where this feature has been a " live " consideration for the decisions of various Boards.

9. Conclusion

I hope this Paper has brought out a number of thoughts within the terms of its title which have been of value to you, and will contribute to the general structure of this total study accorded by the Institution of Production Engineers in this present Conference on Automation.

MARGATE CONFERENCE

DISCUSSION GROUP 2D

AUTOMATIC CONTROL IN THE PETROLEUM INDUSTRY—A CASE STUDY

by I. McCALLUM, B.Sc.

Mr. McCallum has been associated with the petroleum industry since 1928, and has worked in many parts of the world. After taking a B.Sc. degree in chemistry at University College, London, he joined the Anglo-Iranian Oil Company in Abadan, and subsequently spent some years in Trinidad as Chief Chemist to a petroleum producing organisation.

In 1942 he went to Canada, where he worked at the Sarnia Refinery of the Imperial Oil Company, Ltd. In 1946, when the Fawley Refinery expansion was imminent, Mr. McCallum was transferred to the United Kingdom and in 1948, took over the position of Technical Superintendent at the Fawley Refinery of the Esso Petroleum Company, Ltd.

Mr. McCallum

THE use of automatic control instruments for the regulation of manufacture in the petroleum industry has long been a recognised practice. The use of such instruments has been a necessary part of the development of the industry, and without such techniques it would have been impossible to achieve the high standard of product quality which the petroleum refineries now produce. The materials handled are, of course, fluids or materials which have been rendered fluid for handling through the type of control equipment which is generally used. In this respect, therefore, the problems that have had to be dealt with are rather different and no doubt simpler than the problems encountered in other industries. However, there is no doubt that much can be learnt from the application in the petroleum industry of these modern techniques.

The basic process in the petroleum industry is one of distillation. The crude oil, which is the raw material, is a mixture of hydrocarbons with a very

wide range in boiling point right down from the gaseous materials such as methane and ethane to the heavy asphaltic material which is used for road surfacing. This raw material is distilled into a series of cuts corresponding in boiling range to the desired end products.

The petroleum industry has made tremendous strides in its methods of manufacture over the last fifty years. In the early days the crude oil was distilled in batch stills. Systems of fractionation were very primitive, and there was very wide overlap in the boiling range of the products. Measuring instruments of any type were little used, and the operation of the units was largely dependent on the skill of the stillman. Later types of distillation plants, based on a continuous system, consisted of a series of shell stills in which the crude oil flowed from one to the other and a series of cuts was taken off from each one of the shell stills on the line. Such a process was still primitive compared with modern practice—very little heat exchange equipment was used, and control systems were usually limited to the regulation of the pumping rate into the first still. Such equipment was hazardous because of the large volumes of hot oil held in the stills, and also inefficient because of the poor utilization of the heat derived from the fuel used in firing the stills. Some of these older units are still in operation and over the years have been continually modified and added to. They are usually very complex now, and certainly more difficult to operate and less efficient than the newer types of equipment.

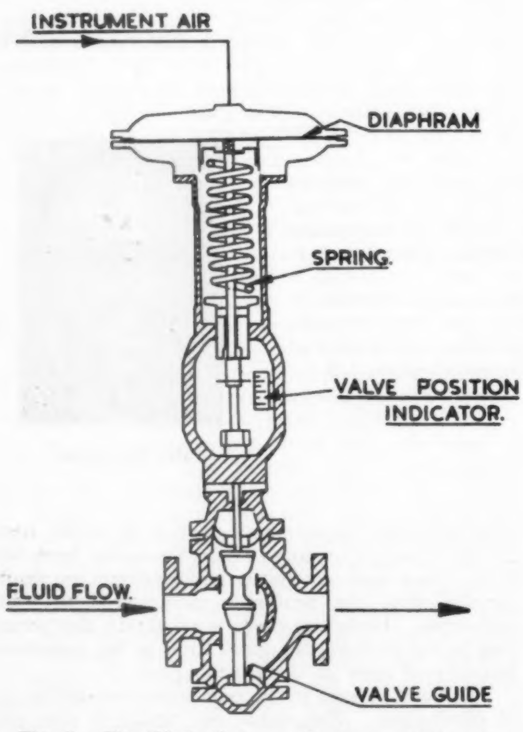


Fig. 2. Simplified diagram of air operated valve.

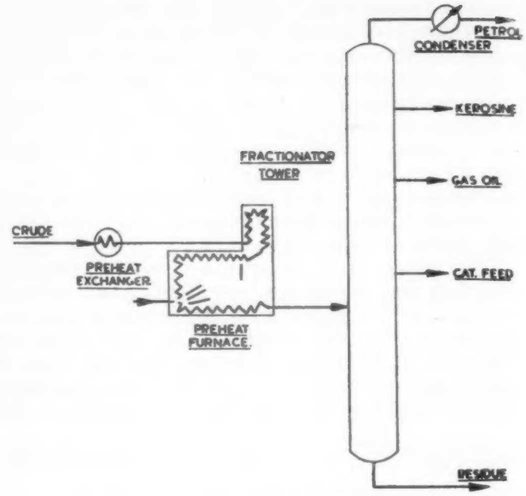


Fig. 1. Simplified distillation equipment.

The development of the pipestill heater has radically changed the basic design of distillation equipment which is shown schematically in Fig. 1. Nowadays this type of plant is fundamentally simple, insofar as it consists of two basic pieces of equipment, namely, the pipestill heater in which the crude oil is heated as it passes through tubes in the furnace, and the fractionating column from the top of which, and from the sides, are taken the required series of cuts. These cuts give the primary splitting up of the crude oil, according to boiling point, and after further processing give us the various petroleum products which we all know as petrol, white spirit, kerosene, autodiesel fuel, gas oil for the gas works industry, marine diesel oils, fuel oils, lubricating oils, and asphalts.

This process has been described as a fundamentally simple one, but it grows tremendously in complexity when the necessary ancillary equipment is added to achieve optimum operation. In order to attain the high degree of quality which is required by the market now, it is necessary to have a very close control on all the operations which are inherent in this process, and this control can only be achieved with automatic instrumentation. For instance, the rate of flow of crude oil through the furnace must be held within narrow limits. The temperature to which this oil is heated in the furnace must be controlled within a few degrees. The temperature in the fractionating tower must be held within narrow tolerances, and this implies very close control of the reflux liquid which runs down inside the tower over the fractionating trays and which varies in different sections of the tower, according to the type of product which is being withdrawn. In order to achieve optimum operation of the fractionating tower, and also to make optimum use of the heat which is generated in the furnace, there is a complicated system of heat exchanger equipment, and the streams passing through these heat exchangers require accurate control of both rate of flow and temperature.

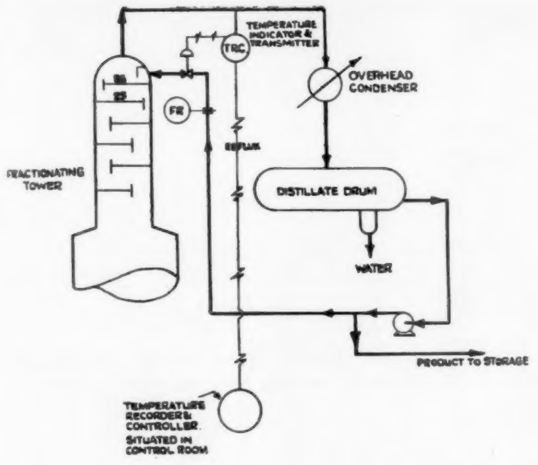


Fig. 3. Typical system of tower top control.

There are, of course, many other types of plant used in the petroleum industry for the further processing of the cuts from the crude oil distillation. In order to make petrol with good anti-knock properties, heavier distillates are converted by cracking. Kerosene and gas oils have to be processed to reduce their sulphur contents and lubricating oils pass through a series of operations to remove wax and unstable components from the raw stocks. All these processes again are controlled automatically as far as the fundamental variables of temperature, pressure and rate of flow are concerned.

The Control Instruments

Turning now to the control instruments themselves, the basic piece of equipment which is used is the diaphragm operated control valve, which is shown in Fig. 2. All types of control on petroleum equipment basically consist of the control of the rate of flow of the fluid, and this valve carries out this function and is operated by a variable air pressure which is imposed on the diaphragm, and which actuates the valve stem. This variable air pressure can come from a variety of measuring and transmitting instruments, according to what it is desired to control. It can be temperature measurement, pressure measurement, flow measurement or any other variable on which the operation depends. There are, of course, many variables of importance for which direct reading instruments have not yet been designed, particularly in the product quality field. To illustrate the inter-connection between a measuring instrument and a control valve, Fig. 3 shows the operation of a typical tower temperature control instrument, where the temperature of the top of the tower is controlled by regulating the flow of the cool liquid being pumped back into the tower. If the temperature rises, then the mechanism is actuated to open up on the control valve, and allows more liquid to pass into the tower, thus having the effect of reducing the temperature.

To illustrate the use of these methods of automatic instrumentation as applied in practice, the operation of the fluid catalytic cracking plant will be described

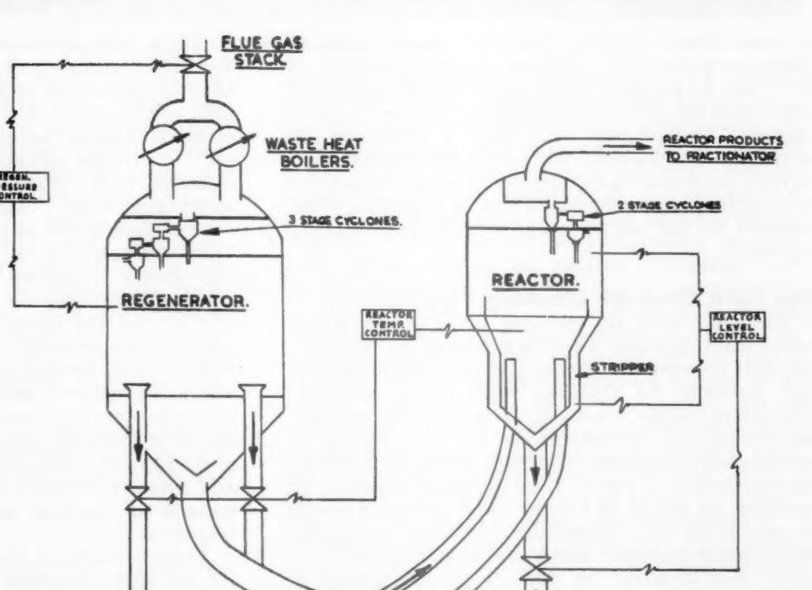


Fig. 4. Simplified flow plan of cracking section, showing chief controls.

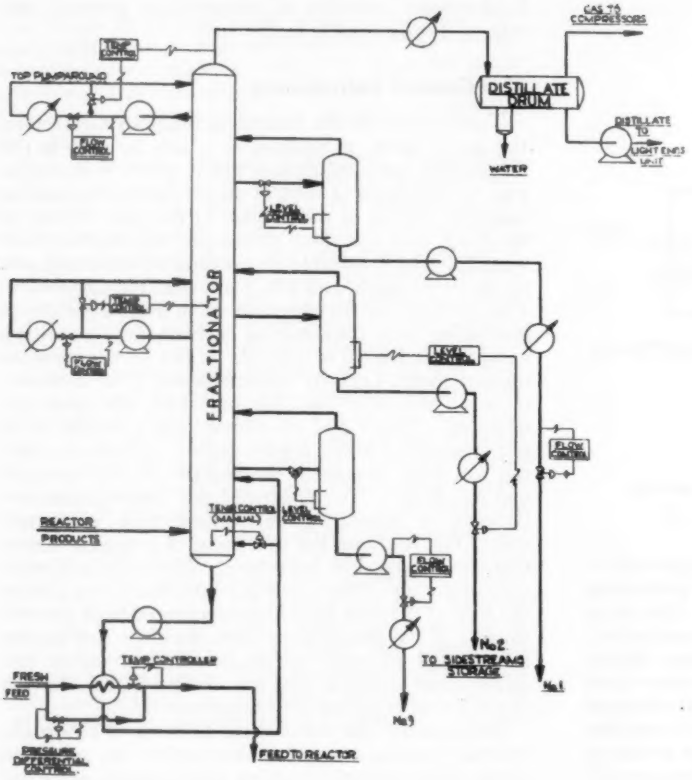


Fig. 5. Flow through fractionating section showing chief controls.

in some detail, showing how the various types of instruments serve to maintain steady operation of the plant as a whole. This plant affords one of the best examples of instrumentation in the modern refinery, because not only does it illustrate the principles of distillation control in the fractionation section, but also shows in the cracking section how the flow of the powdered catalyst can be regulated when fluidised by the use of steam, air and hydrocarbon vapours.

The Fluid Catalytic Cracking Plant

The fluid catalytic cracking plant processes the heavy waxy distillate which is produced on the pipe-still unit between the gas oil and the bottom residue and produces, by cracking, high octane gasoline. This plant consists essentially of two vessels, namely, the reactor and the regenerator as shown in Fig. 4, together with conventional fractionation facilities for the separation of petrol from the other products of cracking, as shown in Fig. 5. The unit as a whole is one of the most impressive pieces of equipment found in the modern refinery and rises to over 200 ft. above ground level. A photograph of the unit is shown in Fig. 6.

In the reactor, the heavy oil is cracked at high temperature and low pressure by passing the oil in vapour form through a bed of fluidised catalyst. In this reaction carbon is formed on the catalyst, which is then circulated to the regenerator, where the carbon is burnt off in the presence of air. From the regenerator the catalyst is returned to the reactor, and so the cycle is repeated. The circulation of catalyst requires no pumps and is operated solely on the principle of having a difference of pressure at different parts of the system due to differences in hydrostatic head. Another unique feature of this type of plant is that no external heat is required. The heat generated from the carbon burning in the regenerator is utilised to vaporise the feed and to supply the heat for the cracking reaction.

Thus, for the correct operation of the plant it is essential to preserve both a pressure and a heat balance, and for this purpose an elaborate system of automatic control becomes a necessity. Moreover it is important to control the condition in the reactor for these cracking conditions affect both the quality of the gasoline yields. In this respect the temperature and pressure at which cracking takes place and the amount of catalyst in the reactor are of prim, importance.

These conditions must be rigorously controlled, for any slight variation in any of them will result in a different degree of cracking and hence a variation in the amount of carbon laid down on the catalyst. This in turn will lead to more or less heat being generated in the regenerator, which will again affect the reactor temperature and the variation in carbon

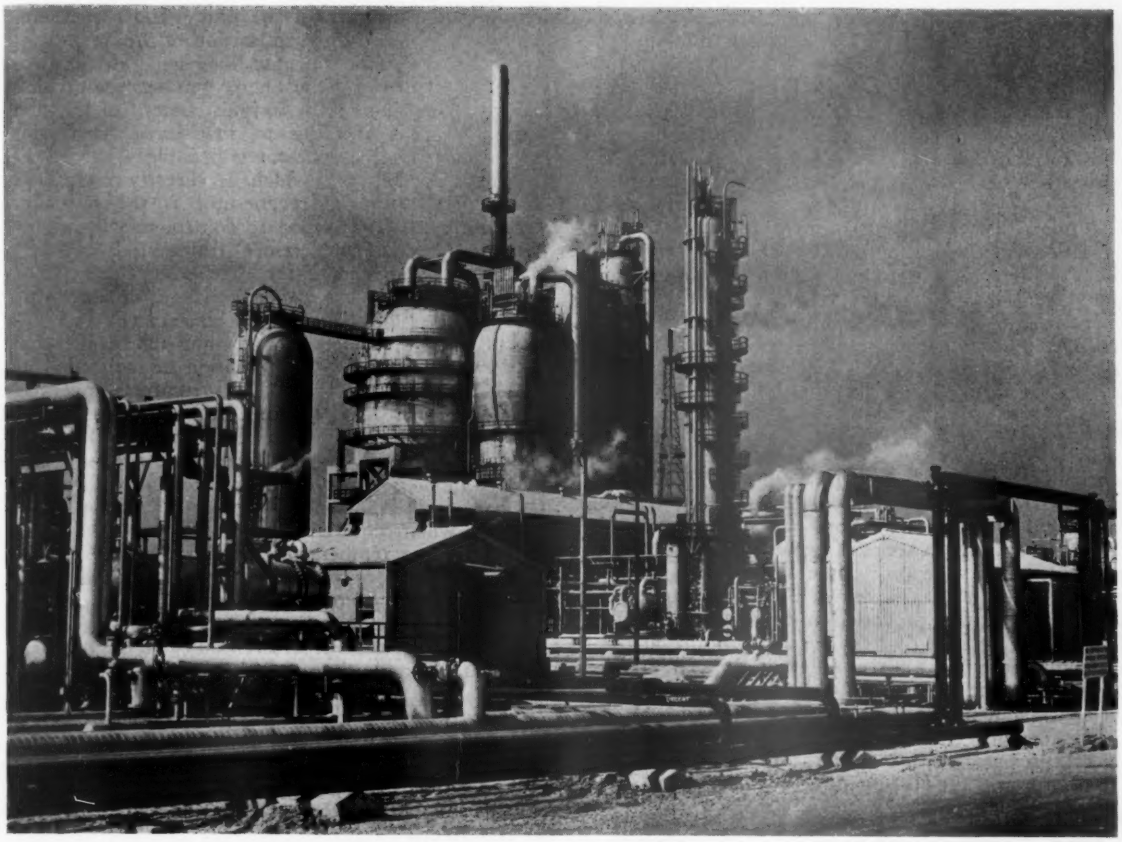


Fig. 6. Fluid catalytic cracking plant.

make will become more marked. Hence, it is evident that without any automatic control, a slight departure from equilibrium will very quickly become magnified and the unit would get completely out of control within a very few minutes. As it is with automatic control, only five men are needed to ensure the smooth running of the unit which will run for long periods of time with only minor adjustment being necessary. The main routine operation required which is not controlled automatically is the addition of fresh catalyst, which is needed to maintain cracking activity and replace losses from the stack. The unit runs continuously for at least a year, when it is shut down for maintenance work which cannot be done during operation.

Having considered the need for automatic control, it will be shown how this control is effected, considering first the control of cracking conditions within the reactor.

Reactor Temperature

Reactor temperature is controlled by varying the rate at which the catalyst is circulated. The flow of catalyst is controlled by slide valves operated by hydraulic oil on the regenerator stand-pipes down which the regenerated catalyst flows to join the fresh feed on its way back to the reactor. Any variation in reactor temperature, as detected by a thermocouple placed in the bed, is transmitted to a temperature controlling instrument, which varies the position of the slide valves until the temperature is again at its set point, so that this instrument compensates automatically for any slight variation in temperature and maintains this constant at any required setting.

Should it be required to alter the reactor temperature without varying the catalyst circulation rate, the temperature to which the feed is preheated can be altered. This is normally controlled by varying the quantity of feed going through a series of six heat exchangers. The remainder of the feed is bypassed. This preheat temperature control is not effected solely by use of a temperature control instrument. A pressure differential controller on the by-pass line ensures a constant pressure drop across the temperature control valve. Thus, any action of the temperature control valve produces an opposite action in the pressure differential control valve. If the temperature control valve opens to allow more feed to go through the exchangers and hence increase the feed preheat, the pressure differential control valve will close until the total pressure drop over the exchangers is the same as previously. This arrangement ensures good temperature control over a wide range of temperatures.

Before entering the reactor, the fresh feed is mixed with two recycle streams drawn from the fractionator. These are at a high temperature and thus the quantity of recycle also influences the total feed preheat temperature. Each stream is controlled by a normal flow controller. It is important to keep these flows constant from another angle—since the greater the percentage of recycle in the total feed, the greater is the amount of carbon laid down on the catalyst—and hence any variation causes a variation of the conditions in the regenerator. The flow controller of one of these recycle streams operates by controlling the steam supply to the recycle pump. The other operates a valve in the recycle line, this stream being taken off the main stream from the bottom of the fractionator which is cooled and returned to the fractionator.

Reactor Pressure

The pressure in the reactor is controlled by the suction pressure at the gas compressors. The cracked vapours from the reactor go into the fractionating tower and the lightest fractions pass from the top of the tower through a series of coolers, where some is condensed into a drum. Here the liquid and gas separate and the gas is drawn off and compressed before being further processed in the light ends plant. Thus it can be seen that the suction pressure at the gas compressors has a direct affect on the pressure in the reactor, the difference being the pressure drop through the drum, coolers and fractionating tower.

The control is effected by varying the steam flow to the compressors which thus alters the speed and hence the pressure on the suction side.

Reactor Bed Level

The amount of catalyst in the reactor is a measure of the time in which the oil is in contact with the catalyst, and hence affects the degree of cracking and the amount of carbon formed. Thus adequate control of the level of catalyst in the reactor is of utmost importance.

The fluidised catalyst within the reactor behaves as though it were a liquid and the problem of measuring the height of the catalyst bed is similar to measuring the level of liquid in a drum. This is done by measuring the difference in pressure between a fixed point below the surface and a point above the surface. Thus, as the level increases, so does the pressure difference. These variations in level are then transmitted to the slide valves through which the spent catalyst is withdrawn from the reactor on its way back to the regenerator.

Regenerator

By controlling the main operating conditions in the reactor just outlined, most of the conditions in the regenerator are automatically set.

It is the object of the regenerator to burn off just as much carbon as is formed in the reactor during the cracking reaction. Failure to do this results in a rapid carbon build-up with serious consequences to the operability of the unit. Alternatively, if too much air is blown into the reactor, there is a risk of excessive temperature rises which could seriously damage the cyclone equipment in the regenerator and might result in a shutdown of the unit. It is, therefore, important to have some indication of the amount of excess oxygen in the flue gases for regenerator control and this is measured by an oxygen recorder which records continuously the oxygen content of the flue gases. By keeping this at low levels, successful operation of the regenerator is possible.

The only variable which is directly controlled automatically in the regenerator is the pressure. Originally it was planned to control this by maintaining a constant pressure differential between the reactor and regenerator. However, this was not found to operate satisfactorily when the unit was commissioned and has not been since used.

The present system of controlling the regenerator pressure is basically a combination of hydraulic oil and air pressure control. The pressure is governed by sliding stack valve dampers on the flue gas leaving the vessel. The pressure of the hydraulic oil supply is controlled partly by the regenerator pressure and partly by compressed air line from one of the control room instruments for the purpose of resetting this variable when required.

Regenerator temperature, while primarily set by cracking conditions in the reactor, is capable of some control. In the event of an excessively low regenerator temperature, two lines of action can be taken. Emergency oil—known as torch oil—can be injected, the heat of combusion of which results in a higher temperature. Alternatively the combustion air can be bypassed through an auxiliary burner and so preheated before entering the reactor. Both of these methods must be employed manually and rarely, if ever, is the regenerator temperature allowed to become so low that recourse has to be made to them.

Fractionator

After leaving the reactor the product vapours are separated into their various streams in a fractionating tower and the control of this operation forms an integral part of the control of the whole system.

The overhead products, as already described, pass through a series of coolers into a liquid-gas separating drum, and are thereafter further separated into the final gasoline products in the Light Ends Unit. In addition, three sidestreams are withdrawn from the fractionator—two of which are steam-stripped to remove light hydrocarbons, before being pumped to storage.

The problem of removing sufficient heat from the tower to effect a good separation is achieved by having a top, mid and bottom pump-around circuit whereby large quantities of the liquid are removed, pumped through coolers and returned to the tower.

Temperatures at different points in the tower are thus controlled both by the amount of cooling and by the quantity of these pump-around streams. Normal flow controllers ensure a steady flow, while temperature controllers, which operate by causing some of the stream to bypass the coolers, control the temperature. The temperature at the bottom of the tower is controlled by varying the quantity of the bottom stream which is returned to the bottom, the rest entering the tower at the top of a heat exchange system located below the fractionating trays.

Fig. 7. Central control room.

The upper and lower side product streams are arranged so that only part of the liquid on the draw-off trays is removed to the stripper, in the case of the upper stream, or the drum which gives capacity for the pump, in the case of the lower stream. In this system the level in the stripper or drum is controlled by a level controller actuating a control valve on the line between the stripper and the tower. The flow of sidestream is controlled by a flow controller down-stream of the stripper.

In the case of the mid-product sidestream, however, all the liquid on the draw-off tray is removed to the stripper. Here, the stripper level controller actuates a control valve on the discharge side of the pump. The pressure in the fractionator being dependent on that of the reactor is set, as already described, by the suction pressure at the gas compressors and is not capable of independent control.

The liquid level at the bottom of the tower is another important variable that has to be controlled. Formerly this was done manually by adjusting the amount of the lower side stream product that was withdrawn. Recently, however, by connecting an air-line between the bottom level recorder and the lower sidestream take-off control instrument, the level in the fractionator has been successfully controlled automatically.

Emergency System

There are many emergency precautions which are designed to deal with almost any unusual situation that may arise on the unit. Should the flow of air used for the regenerator fall below a certain level, steam is automatically injected into the air line to ensure that there is a sufficient flow to carry the catalyst into the regenerator.

If the feed rate falls to half the normal, steam is automatically injected into the feed to prevent the catalyst plugging on its way to the reactor.

Precautions are also taken to deal with an emergency should there be a failure at the gas compressors. To avoid a build-up of gas pressure, this is automatically released to the flare when it exceeds a certain predetermined limit. All the gas can be diverted to the flare by operation of a switch in the control room, if the necessity arises.

In the central control room illustrated in Fig. 7 all the measuring and control instruments are located. The photograph shows not only the conventional type of instrument lay-out, but also the graphic panel system, which is a fairly recent development. The graphic panel, using a small type of instrument, incorporates a picture of the flow through the unit by arranging the instruments on a simplified flow plan and so giving the operator a more logical representation of the way the plant is operating. From this central control room the whole plant is run and if any of the variables drift away from desirable levels, then there is a system of alarms which warn the operator that adjustments are necessary. In addition to the controlling instruments, a large number of temperature measurement points are brought into the control room so that periodical checks can be carried out on various parts of the unit which are not under automatic control. Thus there are some twenty temperature points in the regenerator so that any localised overheating can be detected.

Future Developments

The above description has shown how a single refinery unit has been developed to a high degree of automatic control. However, there is one very important feature which is lacking and which should set the pattern for the future. The prime purpose of a refinery unit is to make products to a predetermined quality level. The automatic control on a unit is set solely on operating conditions and not on what we are really trying to control, namely product quality. At present this is done by carrying samples to the laboratory where they are analysed, in some cases, by quite time-consuming methods, the results being passed back to the plant where the necessary

adjustments are made to the operating variables. The reason for this is simple, namely, that the necessary instruments do not yet exist or if they exist, as they do in some cases, have not been brought yet to a sufficiently high standard of reliability for plant control. If such instruments could be designed which would give rapid product quality control on the units, then much more rapid adjustment of plant conditions would be possible, with increased efficiency of operation and saving of manpower. Great strides are being made in the development of rapid methods of laboratory analysis by instrument manufacturers, such as the use of infra-red spectrometry, mass spectrometry, gas chromatography, and many other techniques, all of which point the way for possible methods of control. A certain amount has of course already been done in this field, but it only touches the fringe of the problem because of the diversity of product quality analyses which ideally would be required. There are well over a hundred different tests which are carried out on the wide range of products made in a petroleum refinery. However, there are certain key tests for which instruments would be of great and immediate value.

There are now instruments on the market which measure automatically the viscosity of liquids, and such instruments should certainly find a place in the industry for viscosity control of products. They could be applied readily to the distillation of lubricating oil cuts, which call for very close control of viscosity on the primary distillation to ensure correct product quality in after processing. Again, the blending of the various fuel oil grades manufactured requires close checking on viscosity to avoid excessive use of the more valuable light components.

The sulphur content of petroleum products is a point of very great importance nowadays, particularly with the advent of high sulphur Middle East crudes. Sulphur is removed from products such as kerosene and gas oil by extraction and hydrogenation processes, and plant control of this product quality point would be invaluable in improving the operation of the units. However, this again is something for the future.

Another line of development which will, one day, no doubt play its part in advancing automatic control in the petroleum industry is the use of electronic computing equipment. For example, the catalytic cracking process discussed above is an operation of very great complexity, in that there are a great number of variables controlling the operation—not only the physical variables of the unit, but also the chemical variables of product quality on feed, products and catalyst. Accordingly, in order to establish whether the unit is running at a level of optimum profitability it is necessary to carry out very lengthy and time-consuming calculations. These calculations can be readily done on a computer, and it should be possible in the future to integrate such calculations with direct control of operating variables on the unit.

In conclusion, it should be mentioned again that a modern petroleum refinery consists of a multiplicity of processing units, each of which is controlled automatically but controlled as a separate entity, largely unrelated, as far as instrumentation is concerned, with adjacent plants. The plants draw from tankage and discharge into tankage. The day is far distant when a complete refinery can be operated from a single control room. The cost of the necessary instrumentation might well rule out such a possibility. However, there is already one development which points in this direction, and that is the use of automatic gauging of tankage transmitting to a central point. Such equipment is already on the market and should have wide application in the future.

Finally, as mentioned earlier, the development of automatic control in the petroleum refining field has been largely the result of technical necessity rather than the result of efforts to reduce operating labour costs. The number of operators on a process unit has never been very large, and the greatest rewards from the use of automatic equipment have been found in the field of getting better yields of more valuable products from the raw material.

NEW BUILDING FUND APPEAL

Since the publication of the last list, donations have been received from the following subscribers. (The list was compiled for press on 19th July, 1955).

J. Bingham, M.I.Prod.E.
F. R.Bradshaw, A.M.I.Prod.E.
A. A. Dickson, A.M.I.Prod.E.
B. F. Goodchild, M.I.Prod.E.

Melbourne Section:-
W. T. Barry, A.M.I.Prod.E.
J. R. Bridge, A.M.I.Prod.E.
J. Carter, A.M.I.Prod.E.
R. Deutsher, M.I.Prod.E.
J. M. Dick, Stud.I.Prod.E.
W. Fowler, M.I.Prod.E.
D. McKelvie, Stud.I.Prod.E.
Pauer & Co. Pty Ltd.
C. Pullen, M.I.Prod.E.
E. Rodeck, A.M.I.Prod.E.
J. Steer, M.I.Prod.E.
Sir Fred Thorpe, M.I.Prod.E.
L. W. Worthington, A.M.I.Prod.E.

E. Martin, A.M.I.Prod.E.
Eric Paton, Limited.
W. E. Simpson, Grad.I.Prod.E.
N. H. Vincent, A.M.I.Prod.E.

BIRTHDAY HONOURS

The Institution records with pleasure that Her Majesty the Queen has conferred the following awards on members of the Institution :-

O.B.E.

Mr. R. A. Wright, Member, Works Manager, Skefko Ball Bearing Company, Luton.

M.B.E.

Mr. E. Ayland, Associate Member, Works Manager, Engineering Division, John Curran, Ltd., Cardiff.

Mr. W. G. Bennett, Works Manager, Climax Rock Drill and Engineering Works, Ltd., Redruth.

Mr. J. W. Gardner, Associate Member, in charge of new development and process engineering, D. Napier & Son, Ltd., Liverpool.

Mr. A. Sykes, Member, Technical Director of David Brown & Sons (Huddersfield) Limited, has recently completed fifty years' service with the Company. To commemorate the occasion, Mr. Sykes was presented with a silver rose bowl by his fellow directors at a luncheon in his honour on 8th June. Mr. Sykes, who is 67, joined The David Brown Company in 1905 and has successively held the positions of chief engineer, works manager, engineering controller, and technical director. He is acknowledged as one of the leading experts on gear production and is a member of Council and a former Chairman of the British Gear Manufacturers' Association. Mr. Sykes has been a member since 1929 and chairman since 1940 of the British Standards Committee—Gears and Gear Hobbing Machines, and is the leader of the British delegation to the International Standards Committee dealing with gearing production. He has also been a member of the Admiralty-Vickers Gearing Research Association since its inception, a member of the Mechanisms and Metrology Committee of the Mechanical Engineering Research Organisation, and is a Past President of the Yorkshire Section of the Institution.

Mr. John Blakiston, Member, has been elected Junior Vice-President of the Institute of British Foundrymen for 1955/56. Mr. Blakiston is a foundry consultant and a director of W. Richards & Sons, Ltd., and the Sandholme Iron Company Ltd. He is a member of the Institution of Mechanical Engineers, and was recently made a freeman of the City of London.

Mr. G. L. Brough, Member, has now taken up an appointment as Engineer I.C. Dockyard, with Gray, Mackenzie & Co. Ltd., Basrah, Iraq.

Mr. F. G. S. English, Member, recently took up an appointment as Deputy Managing Director of Auto-Graph International Limited, Brighton. Mr. English is a member of the Institution's Research Committee and Chairman of the Production Control Sub-Committee.

Mr. W. H. Mather, Member, has been appointed Director and General Manager of The Head Wrightson Machine Co. Ltd., Middlesbrough.

Mr. Frederick J. Tector, Member, General Manager of the Manganese Bronze and Brass Company Limited, Birkenhead, has been elected President of Wallasey Rotary Club.

Mr. S. Carroll, Associate Member, has taken up an appointment as Personal Assistant to the Chief Engineer in the Toronto plant of Johnson, Matthey & Mallory Limited.

Mr. R. P. Davies, Associate Member, has taken up an appointment as General Manager with William Bodden & Son Limited, Oldham.

Mr. Sykes *(on right)* receives the silver rose bowl.

Mr. F. W. Whitehead, Member, Chief Production Engineer of the Engine Division of the Bristol Aeroplane Co. Ltd., recently retired after 34 years' service with the Company. Almost all the engine division as it exists today was planned by Mr. Whitehead and as a result of his work he has become acknowledged as one of the outstanding machine tool engineers in the country. He has been a member of the Company's engine divisional board since its inception in 1944. Mr. Whitehead was the first President of the Western Section of the Institution.

Mr. Whitehead

Mr. James T. Foster, Associate Member, has resigned his appointment with Babcock and Wilcox, Ltd., in consequence of his appointment as Training Officer to the Burmah Oil Company (Burmah Trading) Ltd., which is a joint enterprise of the Burma Government and the Company.

Mr. Foster asks that any firms willing to accept Burmese students as visitors during their training in England should get in touch with him c/o his Company at 604 Merchant Street, Rangoon.

Mr. R. H. Garner, Associate Member, formerly Principal of the Burnbank School of Engineering, was recently appointed Principal of Coatbridge Technical College.

Mr. R. A. Gill, Associate Member, who was previously employed at Canadian Arsenal, Scarborough, Ontario, has now moved to Cleveland, Ohio, where he has taken up a position as a Tool Designer with the Warner and Swasey Company.

Mr. F. Hallworth, Associate Member, is now Engineer II at R.O.F. Maltby, near Rotherham.

Mr. L. R. Houghton, Associate Member, is relinquishing his appointment as Senior Lecturer in Management and Work Study at the Leicester College of Technology to take up an appointment on 1st September, 1955, as head of management and supervisory development with the Bahrein Petroleum Company, Persian Gulf.

Mr. S. S. Jauhari, Associate Member, has been promoted to Assistant Director General, Ordnance Factories, Calcutta, India.

Mr. J. E. Lissaman, Associate Member, has relinquished his appointment with the New Zealand Government in the Department of Labour and has taken up a position with Balm Paints (N.Z.) Limited, as Works Engineer.

Mr. F. Scammell, Associate Member, has now left the service of Hoover (Washing Machines) Limited, to take up the post of Assistant Works' Manager with Lines Brothers (South Wales) Ltd.

Mr. W. N. Axtell, Graduate, has relinquished his appointment with De Havilland Propellers Limited, and has taken up an appointment as Assistant General Manager, Fownes Forge and Engineering Co. (1928) Ltd., Cardiff.

Mr. D. J. Foster, Graduate, has recently been appointed Head of the Work Study and Phototype departments of the Western division of the Export Packing Service.

Mr. K. A. G. Giles, Graduate, has recently relinquished his appointment as Senior Planning Engineer with Humber Limited, Coventry, and has now taken up an appointment as Commercial Production Engineer with British Engineers Small Tools and Equipment Co. Ltd.

Mr. L. Taylor, Graduate, has taken up the position of Development Engineer with Washington Chemical Co. Ltd., Washington, Co. Durham.

Mr. D. A. Thomas, Graduate, has been employed as a Technical Assistant by the Ford Motor Company since his demobilisation in March.

Mr. B. R. Westwell, Graduate, has been appointed to the post of Factory Engineer and Manager of Polythene Production at the Jamaica factory of The Metal Box Company (B.W.I.) Limited.

OBITUARY

The Institution records with deep regret the death, in April last, of **Mr. William M. B. Fowler,** Member, of the Melbourne Section. Mr. Fowler was a foundation member of the Section in 1942, and served continuously on the Section Committee from 1946 until his death. He had also held office as President of the Section, and represented the Section on the Australian Council for the past eight years, during which time he served for a period as Chairman.

In notifying the Institution of Mr Fowler's death, the present Chairman of the the Melbourne Section, Mr. C. Pullen, paid the following tribute: "Bill Fowler served the Institution with unswerving loyalty, devotion and enthusiasm for the past nine years, and those of us who were privileged to be his colleagues will sadly miss his wise counsel in our future deliberations".

(*continued from page* 495)

"Still looking to the future I believe that this Institution will continue to inspire its members to work hard and to do worthwhile things. What is it that makes us do this? I believe we are a virile group; we hit each other pretty hard but we come back on the rebound, and are still friendly with each other. We go on doing a good job because we are enthusiasts, and I think that enthusiasm in the midst of technical change and other difficulties is one of the vital things which we must preserve for the future. Presidents are transient, but I know that this spirit will continue within the Institution.

"I am sorry that Sir Leonard Lord, is not able to be here this evening, but if I can speak to our absent incoming President, I would say that he will have the backing of a lively, enthusiastic, hard-working and hard-hitting Council, and I do not think he will ever make the mistake of thinking he has been annointed instead of appointed. The President gets as many hard hits in this Institution as anyone else.

"I wish to thank you, Mr. Chairman, personally for the opportunity to come into this wonderful place this evening to have this dinner, for enabling us to get together, for the many kindnesses that I have had from you in the past, and for the great honour that you have done me this evening."

Lord Sempill then called upon two Past Presidents of the Institution, Major-General K. C. Appleyard, C.B.E., and Sir Cecil Weir, K.C.M.G., K.B.E., to reply to Sir Walter Puckey.

General Appleyard observed that he had said at Margate what he felt about Sir Walter Puckey. He had met him first when he himself was a very new boy as President-Elect, and Sir Walter was the Chairman of Council during his term of office as President. He supported, encouraged and educated the President and tried to keep him on the rails as much as he could. General Appleyard doubted if this Institution, in seeking all through the country, could have found a man who was more devoted to the Institution and to the work that he had to do than Walter Puckey had been.

Sir Walter had said that this was an Institution of young men. The address which he had given that night was on the same plane as the address which he had given to most of the Sections in the country which the Institution's young men had attended and to whom he himself must have been a source of inspiration. This business of production engineering was a young man's job, even more than it was an older man's job, and therefore the inspiration must necessarily come to those young men from the men who were at the top, whether it was in the Institution or in their own firms.

In General Appleyard's view, this country had always been very fortunate in the men who were prepared to give up their own private interests and devote themselves, or a considerable portion of their time, to public work, and he did not think that any who knew Walter Puckey could fail to realise that he himself had made many sacrifices in devoting himself to public work, whether it be for the nation or for the Institution.

Therefore, concluded General Appleyard, he thought he could express on behalf of everybody there their sincere gratitude to him for the work he had done and the energy, the kindness and the warm-heartedness which he had shown to all of them and to the Institution as a whole. They owed a very great deal to him, and he had the admiration and affection of everybody who had come into contact with him in the work of the body of which they were so proud.

"Before I sit down", said General Appleyard, "I think you would all like me to say what has already been said by the Parliamentary Secretary, and that is, how grateful we are to Lord Sempill for arranging this party. Lord Sempill is not the senior Past President of the Institution living, but he is certainly the senior Past President here. If you watch him in his activities on the part of the Institution, you find that he is always poking here and there to find out what he can do! It may be small, it may be large, but, always in real kindness of heart, he is poking around to find out what he can do to advance the Institution.

"He made one frightful mistake once, to which I ought not to refer, but he was really responsible for my becoming President, and so I had better refer to it after all.

"Anyway, among all the nice things he has done—I think that Walter Puckey will agree with me—one of the nicest and kindliest things has been this gathering here tonight. I want to say to him on behalf of everybody here what a kindly gesture we thought he made, and how grateful we are to him for making it and allowing us to be here to pay our tribute to our retiring President—may he achieve greater honours than he has already achieved!"

Sir Cecil Weir, in thanking Lord Sempill for the opportunity of saying a few words, said that he was full of admiration for the retiring President of the Institution, whom he knew not only in that capacity, but also as a very valued colleague on the board of his own company. He had been responsible, just as Lord Sempill was responsible for General Appleyard, for bringing Sir Cecil into the Institution. If that were the only thing for which he should be grateful to Sir Walter Puckey, he should indeed be grateful, because it had been for him a valuable education and a very great pleasure to come to know them all and to be associated with an Institution which he believed was making its mark in certain ways even more rapidly than any other Institution. He said that with the greatest respect for the work which was being done by all the other Institutions.

They had seen an example of the Institution's work at Margate. It was without doubt the finest Conference Sir Cecil had attended, and he had attended a good many. Everybody attended the plenary sessions and the discussion meetings, and got great benefit from them too, and for that they owed a special debt of gratitude to three people who were there that night: to Sir Walter Puckey, the President of the Institution; to General Appleyard, who was the Chairman of the Organising Committee; and to their friend, the Secretary of the Institution, Mr. Woodford.

Sir Cecil commented that Sir Walter Puckey made it very difficult for anyone to follow him in any office in the Institution, because he was so outstandingly efficient. He would venture to prophesy that they would hear a great deal about Sir Walter Puckey in British industry in the days to come, and he hoped they would do so, because it would be very good for British industry.

Sir Cecil also expressed his pleasure in listening to the Parliamentary Secretary to the Board of Trade. He came from a Department with which Sir Cecil had had long and happy connections. He had given them a very stimulating and encouraging address and, from the point of view that they wanted to know the views of the present Government, a very appropriate address at that particular time.

Finally, Sir Cecil felt that the Chairman's idea of having this dinner in this distinguished chamber surrounded by every kind of historical atmosphere, and by the traditions of their great country of which they were so proud, was one of the finest things he could have done to show the respect, the regard and the affection that he had, as they all had, for Sir Walter Puckey. He had the greatest pleasure in joining with his friend, Ken Appleyard, with whom he had worked on many occasions and for whom he had a similar respect, in saying how grateful they were to Sir Walter Puckey for his inspiring and stimulating address, and he expressed the sure hope that Sir Walter would continue to take a great interest in the Institution of Production Engineers.

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REVIEWS & ADDITIONS

620.1 STRENGTH OF MATERIALS

"Strength of Materials" by G. H. Ryder. *London, Cleaver-Hume Press Ltd.*, 1953. 278 *pages. Diagrams.* £1. 1. 0.

There has long been a need for a clear and concisely written book such as this, as from past experience it has been found that most text books suffer from the disadvantage of being difficult to read. This book is completely new and offers a modern treatment with clarity of expression in this subject and should be of particular value to students, as the manner of presentation is similar to that in our technical schools and colleges. For this reason alone, it may prove particularly helpful insofar as the student may not have to adjust his mind to a different presentation, and will be able readily to follow the manner of reasoning.

The book is based on the syllabus of the University of London and the contents range through the various forms of stress, shearing force and bending moment, torsion, beams, curved bars and rigid frames, springs, cylinders and spheres, rotating discs, vibrations and critical speeds, etc. The only prior knowledge assumed is of applied mechanics and elementary claculus. There are additional chapters on riveted joints, reinforced concrete and continuous beams and these are carried to a stage which is normally associated with Theory of Structures. Each chapter is complete in itself and starts with assumptions and theory which is built up concisely and logically and, differing from the usual text book, the author does not let the theory comprise the main part of any chapter but carries on to give a wide variety of problems, both numerical and graphical which are of a modern standard. At the end of each chapter there is a list of examples and works of reference for the use of readers wishing to extend their knowledge of a particular branch of the work.

It was a pleasure to see that the section on material testing has been kept to a minimum, sufficient to enlighten the engineer on the value and significance of mechanical properties.

The symbols used suffer some change from those usually accepted and it is up to the student to decide whether or not this has any advantage over the old system.

In short, a good book in every way, and one which should prove an asset to all students preparing for the Higher National Certificate, Professional Institution examinations, as well as those following a degree course.

F.W.H.

667.6 PAINTS

"Paint Testing Instruments" by L. A. Cooper. *London, Sawell Publications Ltd.,* 1950. 72 *pages. Illustrations. Diagrams.* (Based on a series of articles in Product Finishing.)

This small booklet covers a critical review of the more important paint testing instruments which have become established by practice and are available at the present time.

Covering a process such as enamelling, which relies mainly on control and application to ensure consistency of result, a perusal of the contents will quickly give the reader a better appreciation of the equipment which is now available for testing the raw material and also for ensuring quality of the finished work. The review covers instruments suitable both for laboratory use and those particularly applicable for use in the Enamel Shop.

The booklet is divided into four sections:—

1. *Consistency and Viscosity,* covering definitions and terms of expression, general examples of viscometers, flow meters, etc.
2. *Gloss, Colour and Covering Power.* Included in this chapter are accepted standards for "matt", "semi-matt", "eggshell" finishes, etc., methods of measurement such as reflection meters, and also colour comparators.
3. *Instruments for Wet Testing,* covering methods of checking thicknesses, drying time.
4. *Instruments for Paint Performance Tests.* Various equipment is analysed for hardness and durability tests, also climatic tests (i.e. humidity cabinets, salt spray testing, etc.).

A very useful survey of paint testing equipment which can be recommended to everyone concerned with enamel and paint finishing problems. H.L.M.

744 TECHNICAL DRAWING

"Simplified Drafting Practice: A Modern Approach to Industrial Drafting" by William L. Healy and Arthur H. Rau. *New York, Wiley; London, Chapman & Hall Ltd.,* 1953. 156 *pages. Illustrations. Diagrams.* £2. 0. 0.

Ever since the publication of the Productivity Team Report which mentioned the use of simplified drawing office methods in the U.S.A., most Production Engineers will have been wondering what all the fuss was about. This book, describing the methods used by the General Electric Co., U.S.A., will supply the needed information and will enable British readers to decide whether or not there is anything in the technique for them.

The methods described are claimed to simplify delineation, eliminate non-essentials, utilise free-hand drawing and save 20 per cent. to 30 per cent. of the average draughtsman's time without sacrificing clarity or accuracy. In essence, the methods described aim at reducing to a bare minimum the number of lines drawn on paper, by making one view do the work of three and by tracing the bare outlines of complicated assemblies. Where a component, such as a washer, can be described in words it is not drawn.

Neatness and accuracy of measurement in drawings are dispensed with as being non-functional refinements. There is a lot to be said in favour of this viewpoint since the tendency is for the draughtsman to regard a drawing as primarily a work of art instead of a message for the guidance of others.

The authors describe the use of every known time-saving device for drawing office use. These include adhesive transparent tapes for sticking to tracings; the tapes having stock pieces of information printed thereon, thus avoiding some drawing and printing by the draughtsman. The value of producing small size drawing sheets is stressed as yielding important savings in drawing, printing and exertions of the user.

In the opinion of this reviewer, the authors have compared their pet methods with draughting practices that were dropped several decades ago. The authors decry conventional cross-hatching to indicate materials, a practice which is long out-of-date in Britain; they also object to the pictorial representation of screw threads, which also went out with bamboo furniture.

The authors of the book have fallen into the trap of regarding some American conventional practices as the best; for instance, they dismiss the universal draughting machine and drawing table in a few words when, actually, this is the most important labour-saving device ever conceived for speeding up drawing office work. The draughting machine has gained very little favour in U.S.A. drawing offices, where the fixed drawing board and parallel sliding straight edge are the universal equipment. A few simple time and motion study checks would prove easily that the draughting machine is worthy of adoption by all draughtsmen.

There are some good ideas in the book, which could be adopted with profit, but readers should bear in mind that draughtsmen's time can often be saved only at the expense of confusion and wasted time in the machine shop. C.T.B.

621.777 SHEET METAL WORK

"Copper and Brass Pressings, and other products cold formed from strip and sheet." Copper Development Association, *Radlett, Herts.* Revised. *Radlett, the Association,* 1953. 81 *pages. Diagrams.*

This is the fourth edition of one of the publications put out by the Copper Development Association, dealing with copper and its alloys, and is well up to the standard of its forerunners.

As a guide and text book for the student and as a work of reference to the worker or methods engineer dealing with these processes, it would be hard to find a better lay out, beginning at the sheet stage and taking the reader concisely through to the more complicated spinning and forming of these metals. Clear definitions are given of every process, including those needed for joining parts together, and these are considerably helped by the fine photographs and diagrammatic views of types of tools involved.

The typescript is particularly legible, and there is a detailed index and four-page bibliography.

The remainder of the book, 20 chapters, is devoted to the production techniques previously enumerated. Each chapter treats one process, giving a brief but lucid account of the method, and discussing relevant economic and design points upon which decisions must be made regarding its suitability under known circumstances. The liberal photographic illustrations are instructive, adding considerably to the clarity of the book, and some useful data is given in tabular form; e.g. page 151, "Typical Materials for Cold Headed Parts". A tabular summary of the 20 processes, in folder form, is attached to the rear cover.

It is obvious that the author has had the assistance of industrial concerns, specialising in the various processes, which have seized this opportunity to present the particular merits of their activities. By a strictly factual presentation the author has avoided suggestions of sales pushing which sometimes mar such co-operation. The assisting firms are to be complimented on allowing such a wealth of material to be set out so impartially.

This book has its disturbing side. Can American Industry get into production as quickly as is shown on page 30, e.g. "Die casting, several days to several weeks"? Do Americans go so thoroughly into production factors before getting out designs? Is there room for a British counterpart to this book with data drawn from our own Industries? Does it throw a new light on Materials Utilisation? This is a book to raise, as well as answer, many questions. A.J.L.

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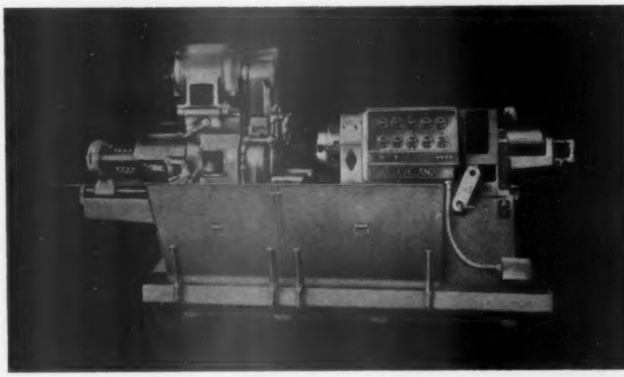

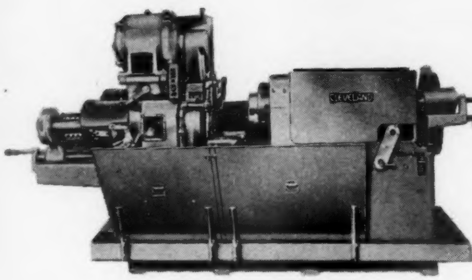

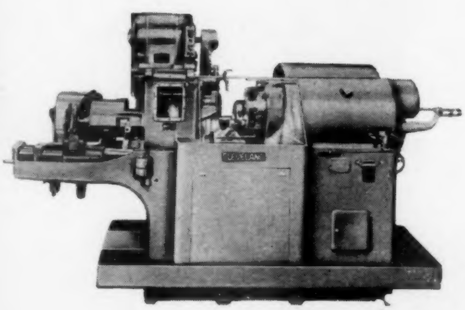

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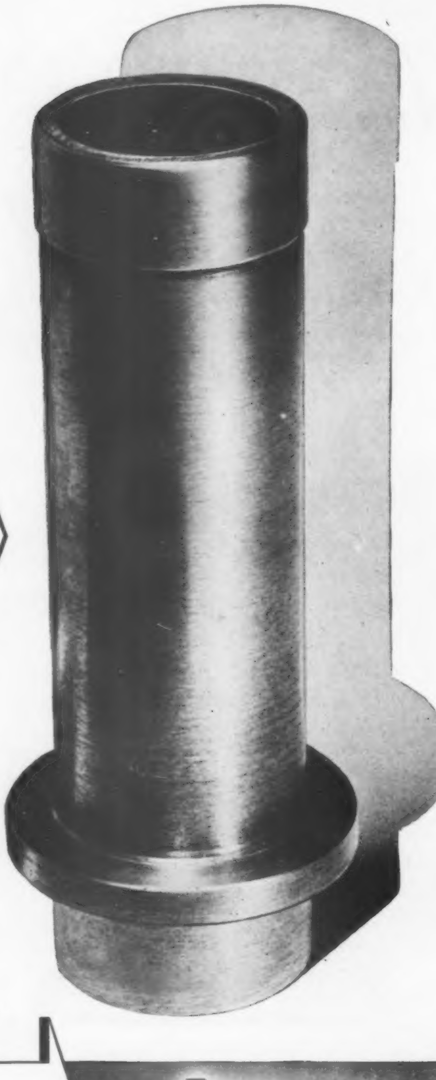

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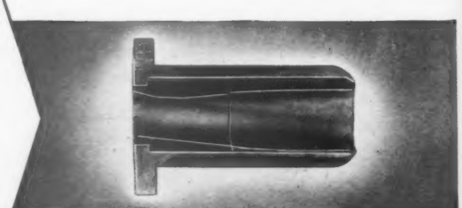

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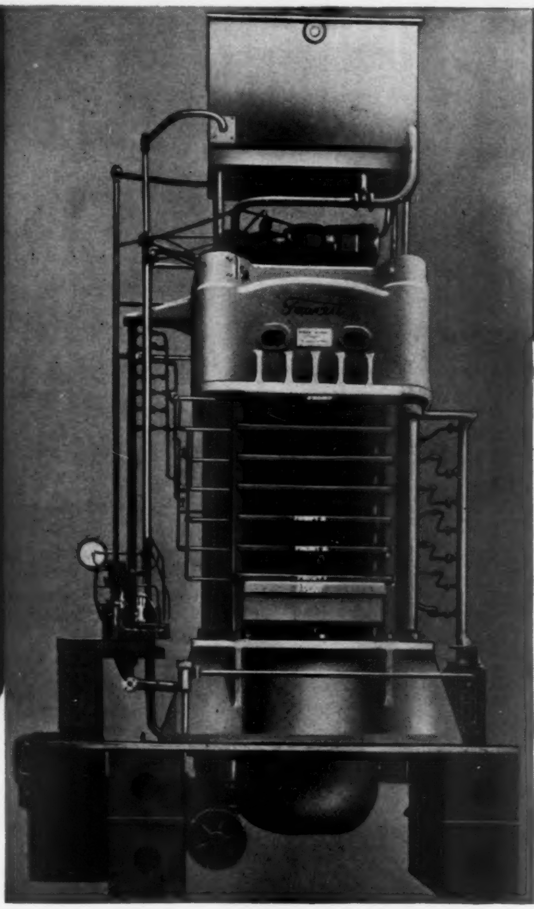
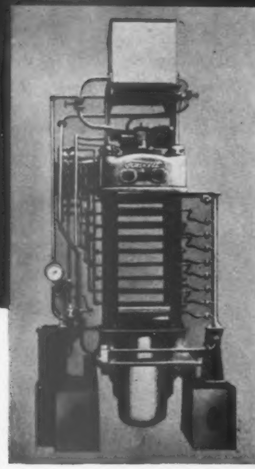
TRADE MARKS
BSA


HEENAN-DYNAMATIC DYNAMOMETERS
are in widespread use for testing all kinds of prime movers. They operate upon the Eddy-Current principle and with the electronic control normally employed, very desirable torque-speed characteristics are provided.
H&F
HEENAN & FROUDE LTD · WORCESTER · ENGLAND


Archdale
HIGH SPEED MEDIUM DUTY
RADIALS
assure high drilling rates on coal cutter gear boxes at
ANDERSON BOYES & Co., Ltd. MOTHERWELL
Over 50 holes ranging from $\frac{1}{4}''$ to $1\frac{1}{16}''$ dia., are drilled and tapped in these cast steel coal cutter gear boxes. Because of their wide speed and feed range, simplicity of control and high penetration rates, ARCHDALE high speed radials assure maximum output on this and many other components in this factory.
SIZES FROM 4 FT. TO 7 FT. RADIUS FOR DRILLING UP TO 3 IN. DIAMETER IN STEEL
machinery



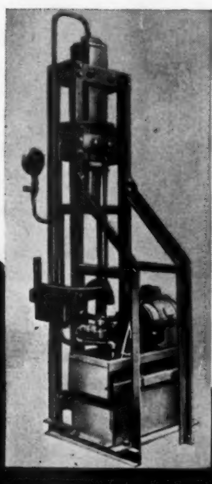


A 500-ton upstroking multi-platen press with self-contained pump and oil reservoir.

Specially designed for the manufacture of brake linings, this 2,000-ton upstroking press has a self-contained motor-driven pump and oil reservoir.

specialists in press design and construction

Fawcett
PRESTON & CO LTD.



A hydraulically operated testing rig with electric motor-driven pump.

We specialize in the design and manufacture of presses for special purposes and production techniques. Wide experience of the needs of industry enables us to build hydraulic presses for widely varying duties. If you have a special pressing or baling problem, Fawcett technicians can adapt a standard machine to your specifications or, if required, design an entirely new press to fit your production requirements.

FAWCETT PRESTON & CO LTD BROMBOROUGH CHESHIRE *TEL ROCK FERRY 2201 (5 LINES)*

A METAL INDUSTRIES MI GROUP COMPANY

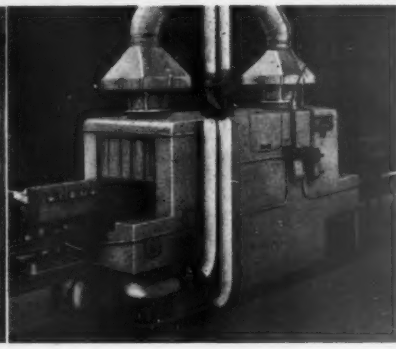
FP8/3/1608

The most practical plant for Cleaning METAL PARTS

PRIOR TO ASSEMBLY, and BEFORE and AFTER REPAIRS

A 'Junior' type machine supplied to a Midlands Motor Car Works

Supplied for the washing and drying of Tractor parts. Crank Shafts, Sumps, Pressings, etc.

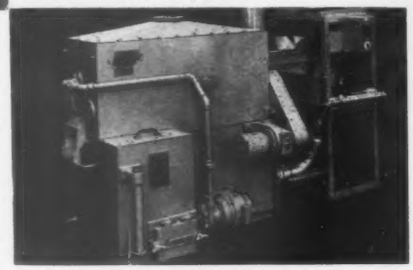


A model 'A' machine, washing parts of motor car engines prior to assembly.

Dawson

DE-GREASING MACHINES

A Rotary Drum machine for removing swarf and grease from small components.



Dawson Metal Parts cleaning machines are supplied for all branches of the engineering industry. Their chief characteristics are robustness of design, small number of working parts and simplicity of operation. Space only permits the illustration of four of the many types of machines built for quick economical washing and drying of Metal Parts.

Sole Distributors

DRUMMOND-ASQUITH (Sales) LTD., King Edward House, New St., Birmingham

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Manufacturers—DAWSON BROS. LTD., Gomersal, LEEDS *Tel.—Cleckheaton 1080 (5 lines)*

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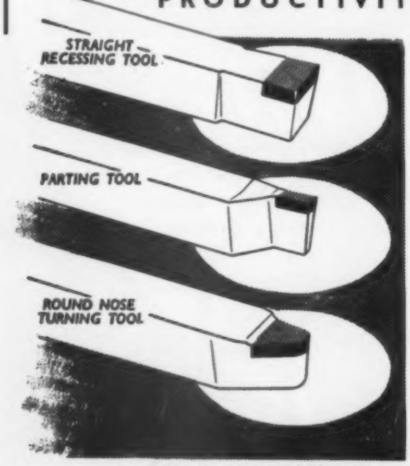
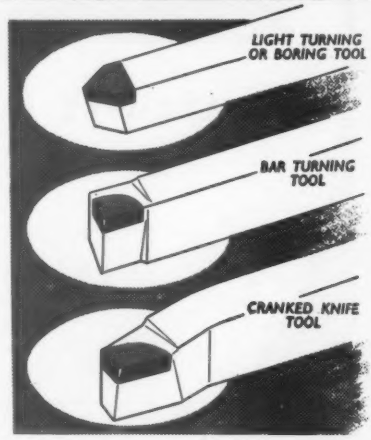
TOOL UP WITH EDIBRAC FOR HIGHER PRODUCTIVITY—BETTER WORK—LONGER TOOL LIFE!



There is a grade of EDIBRAC to cover every machining operation, and our technical staff is always ready to assist with your problems. EDIBRAC is acknowledged in industry as a consistently high quality Carbide—let EDIBRAC prove its worth to you.



Illustrated are a few of the many types of STANDARD Centurion Tools tipped with EDIBRAC—all manufactured throughout in our Works, giving to the customer an obvious saving in cost and guarantee of consistent quality.

For details of our full range send today for a copy of the EDIBRAC Catalogue, which also gives information on the use and maintenance of Centurion Tools.

CENTURION TOOLS TIPPED WITH EDIBRAC

MADE ENTIRELY BY

EDIBRAC LIMITED. CENTURION WORKS, BROADHEATH, Nr. MANCHESTER

dm EC 13

A better method of cutting
NON-FERROUS BARS

Wadkin Parting-off Saw C.Y.

This Wadkin C.Y. with its easy downward cutting action; its combined single lever clamping and sawing motion; its capstan-wheel operated feed and its chute in the main frame provides a faster and better method of repetition sawing off. It will deal with bars up to 4″ × 2½″ or 3″ round. The work is clamped on both sides of the saw ensuring clean cutting and after the cut has been completed it is still held firmly until the saw is raised clear. Components up to 9″ long fall through the chute but if required the machine can be arranged with extended table for cutting off lengths up to 42″ long.

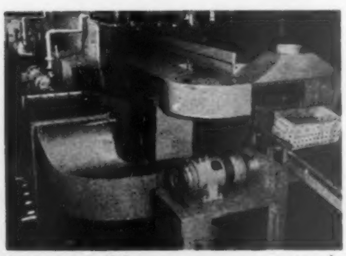
Wadkin *Telephone: Leicester 67114* Wadkin Ltd., Green Lane Works, Leicester. London Office: 62-64 Brook Street, London, W.1. *Telephone: MAYfair 7048-9*

Bratby

INDUSTRIAL CLEANING MACHINES
can be designed to meet your particular cleaning problems

HERE ARE THREE EXAMPLES

This illustration shows a machine cleaning crank cases in the production line. It is equally capable of cleaning small parts in baskets.



A power driven conveyor system is employed with this cleaning machine for ball bearings.

Trays carrying the work are pushed through on a roller conveyor by hand in this cleaning installation.

Whilst offering a very wide variety of standard cleaning equipment, it is BRATBY policy, wherever possible to design the machine to meet the particular cleaning problem. Careful study of each individual problem ensures maximum efficiency and economy of the plant in operation. The illustrations show but a few of the specific types of Cleaning Machines designed by BRATBY for individual needs.

Designed and Manufactured by:

BRATBY & HINCHLIFFE LTD. SANDFORD ST · ANCOATS · MANCHESTER 4

DEDICATED to your SERVICE

A problem presented is a problem solved—when placed before this organisation of technical specialists in metal cleaning and stripping. "S.A.C." service is nation-wide—its representatives able to advise you on the spot—its recommendations backed by the most up-to-date laboratory and manufacturing facilities. "S.A.C." processes cover every phase of cleaning, servicing and protecting all metals during manufacture and maintenance.

PRODUCTION PROVED PRODUCTS

S.A.C.

SUNBEAM ANTI-CORROSIVES LTD.

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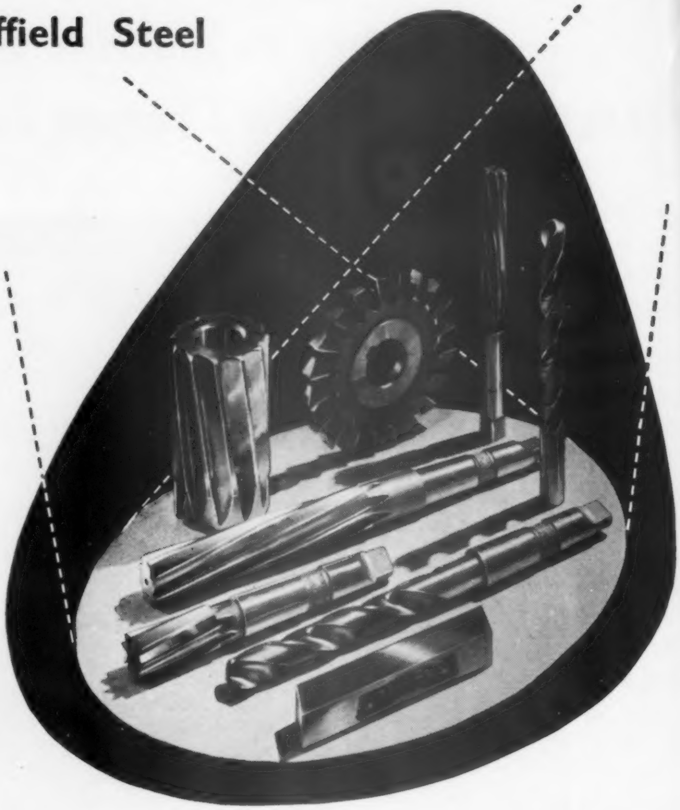
(Regd. Trade Marks)

APPROVED BY ADMIRALTY, WAR OFFICE AND AIR MINISTRY



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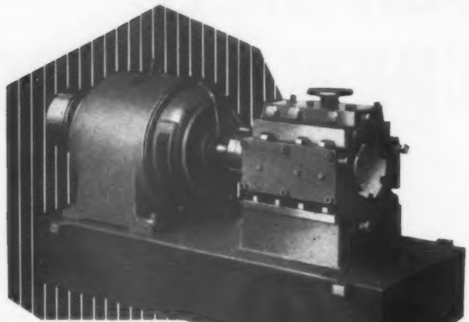
Hydraulic Oils

are approved by

THE *Langdale* ENGINEERING CO

for their High Pressure Hydraulic Pumps



THE
LONDON OIL REFINING CO. LTD.
ESTABLISHED 1890
LORCO WORKS
LONDON, S.E.15 MANCHESTER 11

Model M

4" x 18" SS and SC LATHE

Model 'M'
with reversible centre lead screw

Two ranges of spindle speeds:

Range	Back Gear			Open Belt		
A	66	106	183	480	752	1300
B	99	159	275	720	1128	1950

¾ in. collet capacity

Threads with Standard Changewheels, 4-60 T.P.I.

Feeds with Standard Changewheels.
Surfacing 0.0075 in. down to 0.0005 in.
Sliding 0.015 in. down to 0.0010 in.

- *Illustrated literature available from Stockists or:—*

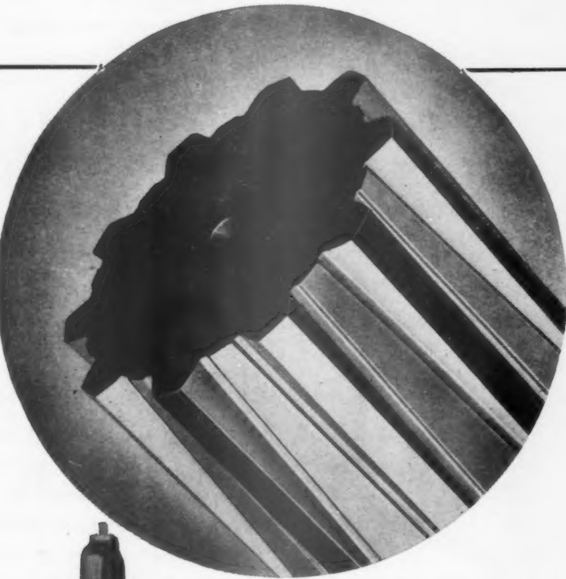
SMART & BROWN (Machine Tools) **LTD.**
25, MANCHESTER SQUARE, LONDON, W.I.
Telephone: WELBECK 7941 (PBX) *Cables:* SMARTOOL · WESDO · LONDON

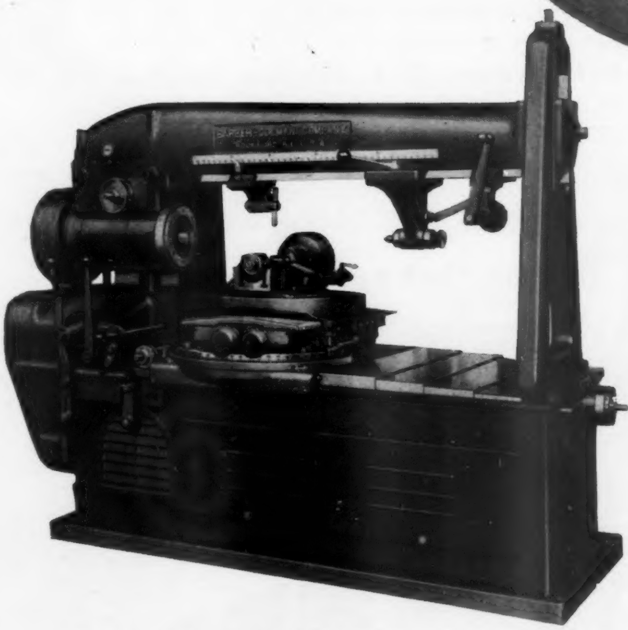
Rainbow

NORTHERN AREA OFFICE: A. V. Green, Britannia House, Wellington Street, Leeds LONDON AREA OFFICE: A. J. Percy, 240, Romford Road, Forest Gate, London, E.7.

another **BARBER-COLMAN** *development*

THE TAPER CORE SPLINE





B-C MODEL 16-11 HOBBING MACHINE
Although designed primarily for hobbing taper splines on shafts, this machine may also be used for general purpose hobbing.

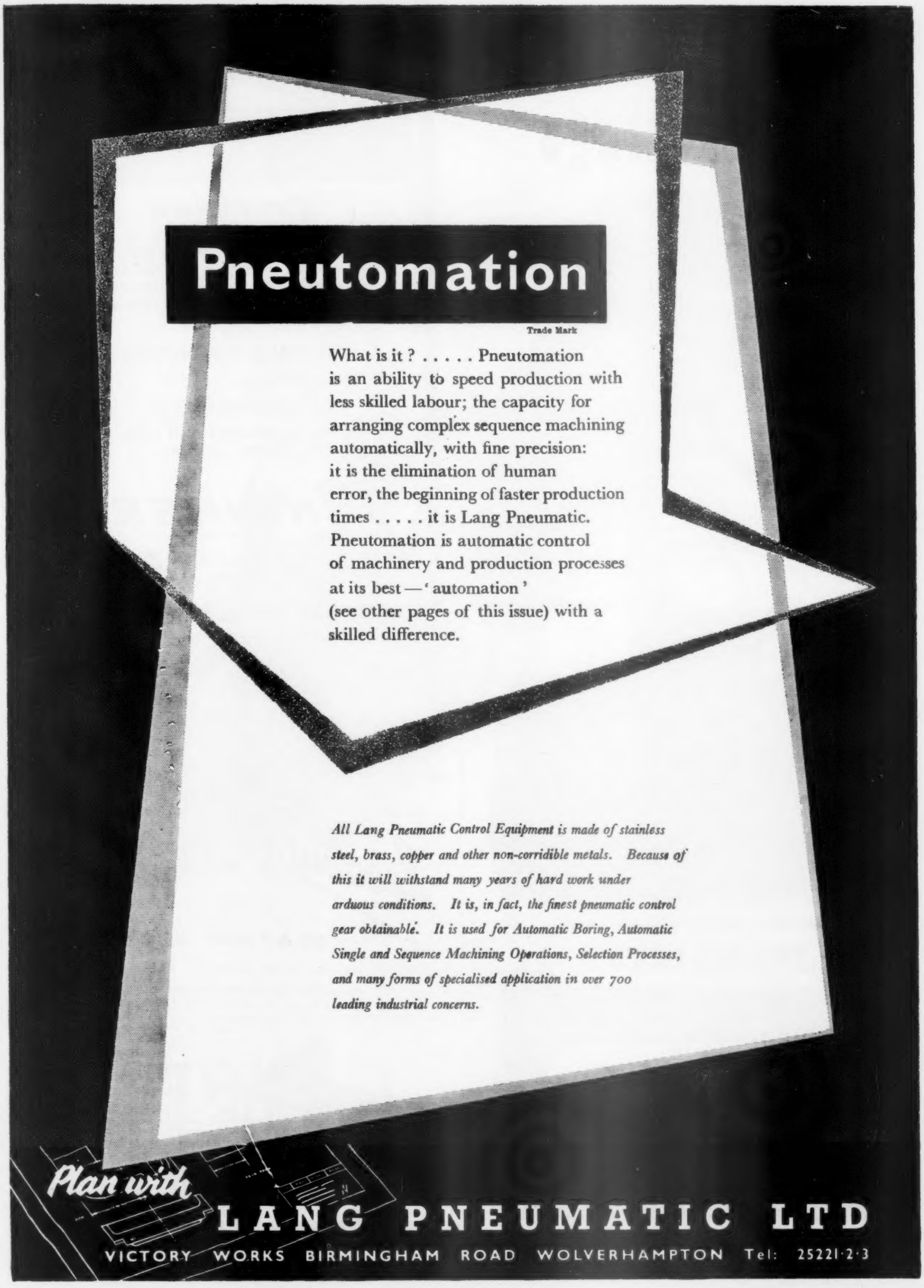
It is the ideal machine for the manufacturer who desires to improve his product by applying taper splines, eliminating the necessity of buying a special machine which could otherwise not be used for general work.

Involute or straight-sided TAPER CORE keys for

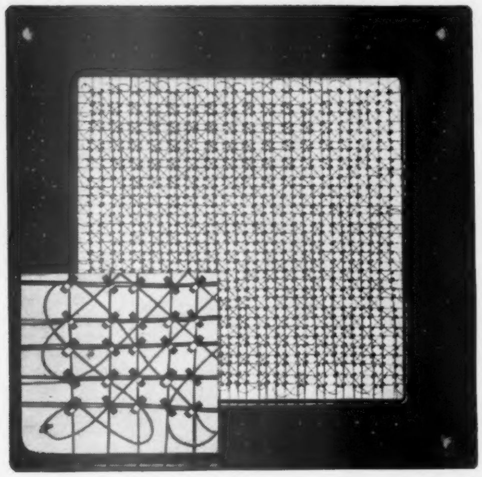
- Greater strength.
- Metal-to-Metal contact.
- Accurate location of Mating parts.
- Greatest security under reciprocating stresses.
- Provides greater area of key contact.
- Saves time and work in assembling a product.
- Eliminates chance key failure.
- Mating parts produced simply by broaching a tapered reamed hole.

BARBER & COLMAN LTD. MARSLAND ROAD, BROOKLANDS, MANCHESTER

Telephone: SALE 2277 (3 lines) Telegrams: "BARCOL", SALE


Pneutomation
Trade Mark
What is it ? . . . . . Pneutomation is an ability to speed production with less skilled labour; the capacity for arranging complex sequence machining automatically, with fine precision: it is the elimination of human error, the beginning of faster production times . . . . . it is Lang Pneumatic. Pneutomation is automatic control of machinery and production processes at its best — ' automation ' (see other pages of this issue) with a skilled difference.
All Lang Pneumatic Control Equipment is made of stainless steel, brass, copper and other non-corridible metals. Because of this it will withstand many years of hard work under arduous conditions. It is, in fact, the finest pneumatic control gear obtainable. It is used for Automatic Boring, Automatic Single and Sequence Machining Operations, Selection Processes, and many forms of specialised application in over 700 leading industrial concerns.
Plan with
LANG PNEUMATIC LTD
VICTORY WORKS BIRMINGHAM ROAD WOLVERHAMPTON Tel: 25221·2·3

Memory Storage Devices are more efficient, more reliable and more compact



A typical magnetic mat ix plane with enlarged portion showin Ferroxcube 2 mm diameter 'D' cores in position.

with FERROXCUBE 'D' GRADE CORES

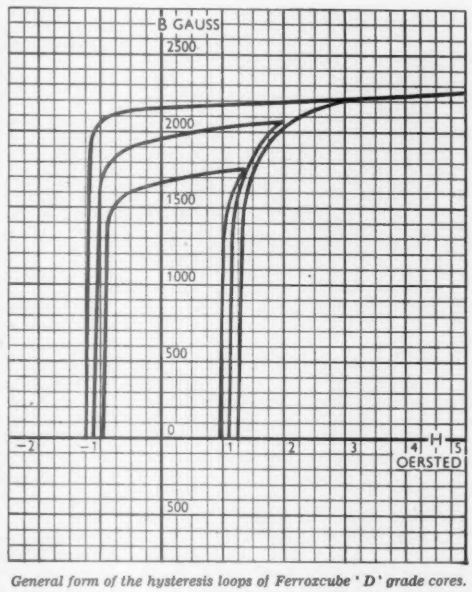
Memory storage devices using magnetic cores have many advantages over alternative systems. They will store intelligence for an indefinite period without consuming power; they permit intelligence to be rapidly withdrawn sequentially or otherwise; and they are extremely reliable.

Following the introduction by Mullard of a special type of Ferroxcube which has a substantially rectangular hysteresis loop, computor designers can exploit the advantages of magnetic systems to the full. Available in two grades, D1 and D2, "rectangular loop" Ferroxcube has a remanent flux density which is at least 90% of its maximum flux density under normal conditions of use. This characteristic makes possible the construction of magnetic core memories with large storage capacities.

Ferroxcube D1 is particularly suitable for use in magnetic shift registers and other switching devices.

Ferroxcube D2 is intended for use in coincident current matrix stores, where it enables switching times of the order of 1μ sec. to be achieved. A typical example of a single plane of a magnetic matrix store using Ferroxcube D2 is that illustrated above, which will store 1024 binary digits.

Full details of Mullard Ferroxcube 'D' grade cores will be gladly supplied on request to the address below.



General form of the hysteresis loops of Ferroxcube 'D' grade cores.

Mullard

'Ticonal' alloy permanent magnets
Magnadur permanent ceramic magnets
Ferroxcube ferro-magnetic cores.

MULLARD LTD · COMPONENTS DIVISION · CENTURY HOUSE · SHAFTESBURY AVENUE · WC2
MC473

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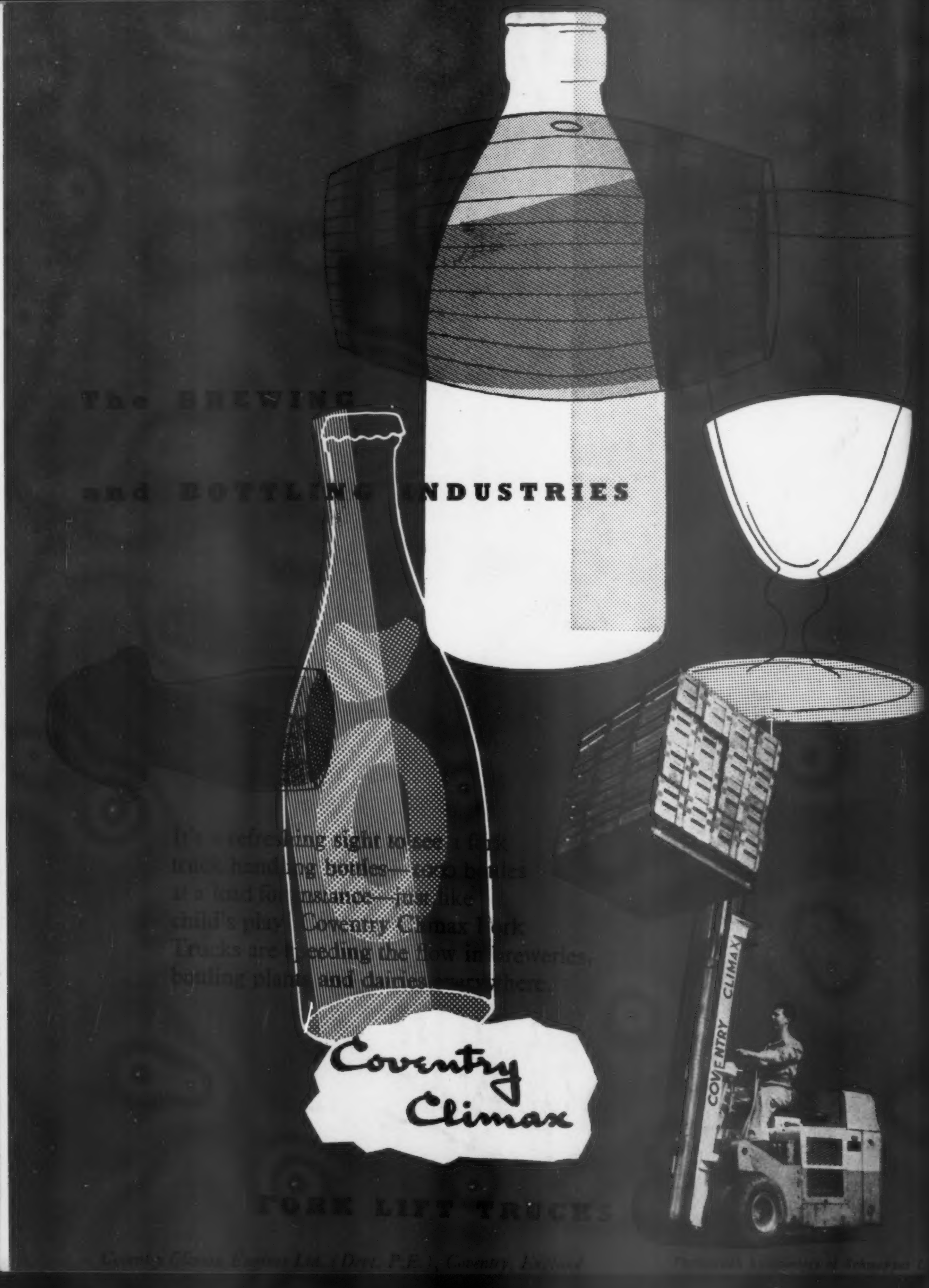
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and BOTTLING INDUSTRIES
It's a refreshing sight to see a fork truck handling bottles—1000 bottles at a load for instance—just like child's play. Coventry Climax Fork Trucks are speeding the flow in breweries, bottling plants and dairies everywhere.
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COVENTRY CLIMAX
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